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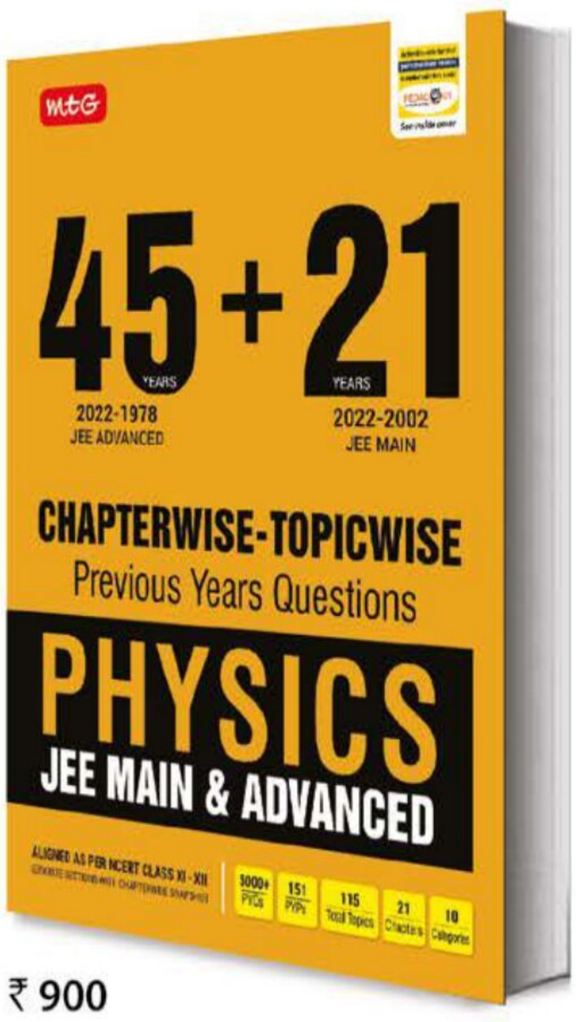


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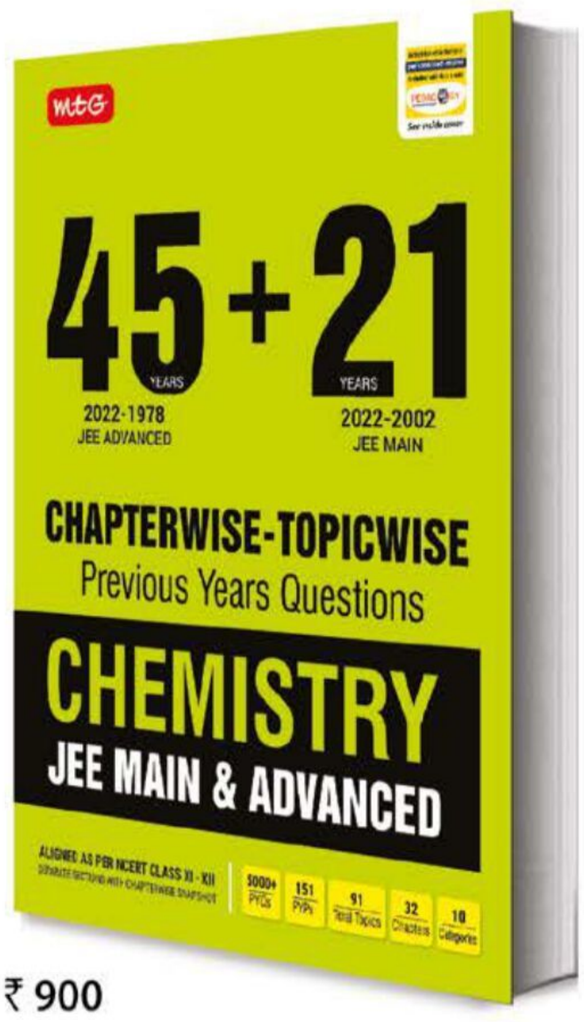


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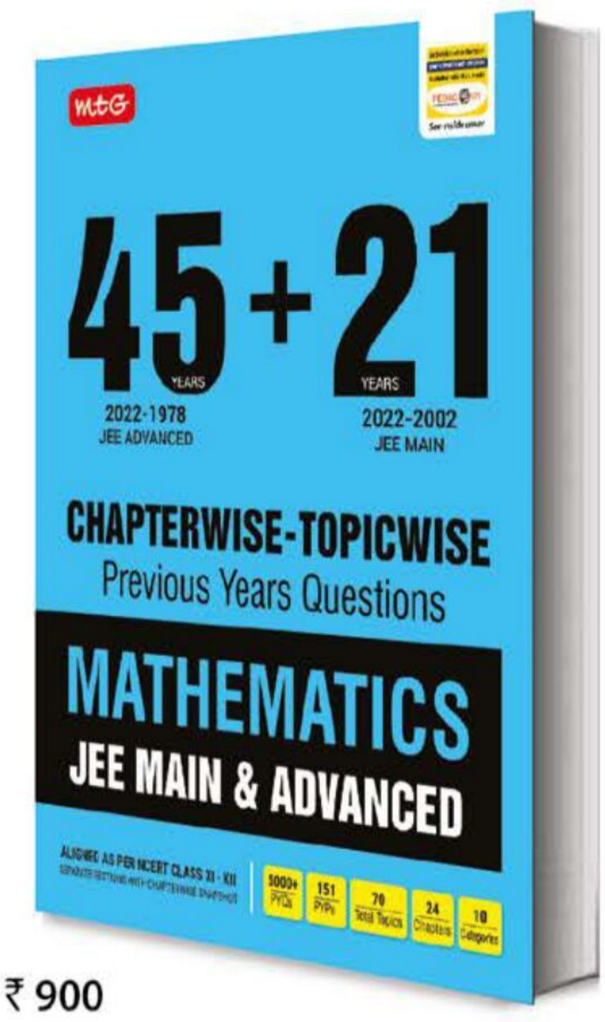


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# CHEMISTRY today

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# CHAPTERWISE PRACTICE PAPER 2023

# CUET (UG)

## SERIES - IV The *p*-Block Elements | The *d*- and *f*-Block Elements

***Section II of CUET (UG) is domain specific. In this section of Chemistry 40 questions to be attempted out of 50.***

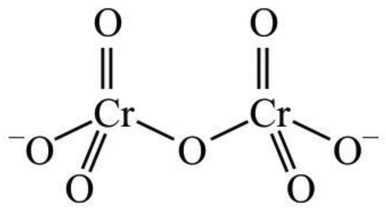
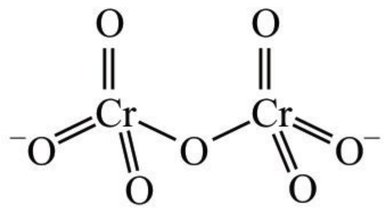
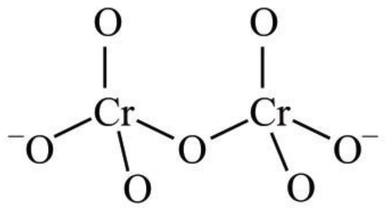
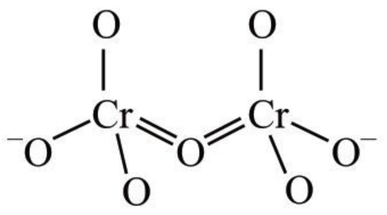
**Time Allowed :** 45 Minutes **Maximum Marks :** 200

### Multiple Choice Questions (MCQs)

**1.** The number of P = O and P–O–H bonds in $H_3PO_4$ are respectively
(a) 3, 1 (b) 2, 2 (c) 1, 2 (d) 1, 3

**2.** Choose the correct statement for transition elements.
(a) Transition elements have low melting points.
(b) Transition elements do not have catalytic activity.
(c) Transition elements exhibit variable oxidation states.
(d) Transition elements exhibit inert pair effect.

**3.** The decreasing order of boiling points of the following hydrides is
(a) $SbH_3 > AsH_3 > PH_3 > NH_3$
(b) $NH_3 > SbH_3 > AsH_3 > PH_3$
(c) $SbH_3 > NH_3 > AsH_3 > PH_3$
(d) $PH_3 > AsH_3 > SbH_3 > NH_3$

**4.** Identify the correct structure of dichromate ion.
(a) 
(b) 
(c) 
(d) 

**5.** Which of the following statements about noble gases is false?
(a) They are used to provide inert atmosphere in many chemical reactions.
(b) They are only sparingly soluble in water.
(c) They form diatomic molecules.
(d) Some of them are used to fill discharge tubes used for advertising signs.

**6.** Among the following ions :
(i) $Cu^{2+}$ (ii) $Ti^{4+}$ (iii) $Co^{2+}$ (iv) $Fe^{2+}$
The coloured ions are
(a) (i), (ii), (iii), (iv) (b) (i), (iii), (iv) only
(c) (ii), (iii) only (d) (ii), (iv) only.

**7.** Select the correct option regarding the properties of dioxygen?
(a) Dioxygen never reacts with metals.
(b) Dioxygen is diamagnetic in nature.
(c) Combination of dioxygen with other elements is a highly exothermic process.
(d) Dioxygen liquefies at 55 K and freezes at 90 K.

**8.** For the oxides of manganese, select the correct increasing order of acidic strength.
(a) $MnO < Mn_3O_4 < Mn_2O_3 < MnO_2 < Mn_2O_7$
(b) $Mn_2O_7 < MnO_2 < Mn_2O_3 < Mn_3O_4 < MnO$
(c) $MnO_2 < Mn_2O_7 < Mn_3O_4 < Mn_2O_3 < MnO$
(d) $Mn_3O_4 < Mn_2O_3 < Mn_2O_7 < MnO_2 < MnO$

**9.** A greenish yellow gas reacts with an alkali metal hydroxide to form a halate which can be used in fireworks and safety matches. The gas and halate respectively are
(a) $Br_2$ and $KBrO_3$ (b) $Cl_2$ and $KClO_3$
(c) $I_2$ and $NaIO_3$ (d) $Cl_2$ and $NaClO_3$.

**10.** When $SO_2$ is passed through acidified $K_2Cr_2O_7$ solution,
(a) the solution turns blue
(b) the solution is decolourised
(c) $SO_2$ is reduced
(d) green $Cr_2(SO_4)_3$ is formed.

**11.** In which of the following sulphur is present in +5 oxidation state?
(a) Dithionic acid (b) Sulphurous acid
(c) Sulphuric acid (d) Disulphuric acid

**12.** Which of the following lanthanoid ions is paramagnetic?
(a) $Ce^{4+}$ (b) $Yb^{2+}$ (c) $Lu^{3+}$ (d) $Eu^{2+}$

**13.** When three parts of conc. HCl and one part of conc. $HNO_3$ is mixed, a compound '*X*' is formed. The correct option related to '*X*' is
(a) '*X*' is known as aqua-regia
(b) '*X*' is used for dissolving gold
(c) '*X*' is used for decomposition of salts of weaker acids
(d) both (a) and (b).

**14.** The general configuration of *f*-block elements is
(a) $(n-2)f^{1\text{-}14}\,(n-1)d^{0\text{-}1}\,ns^2$
(b) $(n-1)f^{1\text{-}14}\,(n-1)d^{0\text{-}1}\,ns^2$
(c) $(n-3)f^{1\text{-}14}\,(n-2)d^{0\text{-}1}\,(n-1)s^2$
(d) $(n-2)f^{0\text{-}1}\,(n-1)d^{0\text{-}1}\,ns^2$

**15.** In the reaction,
$HNO_3 + P_4O_{10} \rightarrow 4HPO_3 + X$, the product *X* is
(a) $N_2O_5$ (b) $H_2O$ (c) $NO_2$ (d) $N_2O_3$

**16.** Which of the following is the most basic?
(a) $Ce(OH)_3$ (b) $Lu(OH)_3$
(c) $Yb(OH)_3$ (d) $Tb(OH)_3$

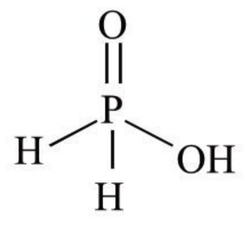
**17.** Which of the following statements is not correct about the structure of $PCl_5$?
(a) $PCl_5$ has a trigonal bipyramidal structure.
(b) The three equatorial P–Cl bonds are equivalent.
(c) The two axial bonds are different and longer than equatorial bonds.
(d) Equatorial bond pairs suffer more repulsion than axial bond pairs.

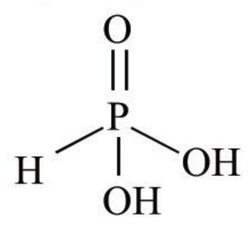
**18.** Cerium ($Z = 58$) is an important member of the lanthanoids. Which of the following statements about cerium is incorrect?
(a) The common oxidation states of cerium are +3 and +4.
(b) The +3 oxidation state of cerium is more stable than +4 oxidation state.
(c) The +4 oxidation state of cerium is not known in solutions.
(d) Cerium (IV) acts as an oxidising agent.

**19.** Name of the synthetic radioactive element of group 16 having atomic number 116 is
(a) Livermorium (b) Tennessine
(c) Flerovium (d) Moscovium.

**20.** Which of the following reactions is not correct?
(a) $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$
(b) $2MnO_2 + 4KOH + O_2 \rightarrow 4KMnO_4 + 2H_2O$
(c) $2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$
(d) $K_2Cr_2O_7 + 7H_2SO_4 + 6KI \rightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 3I_2 + 7H_2O$

**21.** The structural formula of orthophosphoric acid is

(a)



(b)
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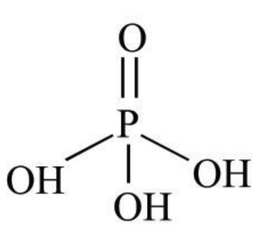
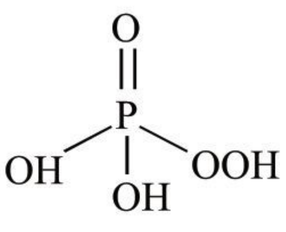



(d)



**22.** An explosion takes place when conc. $H_2SO_4$ is added to $KMnO_4$. Which of the following compounds is formed?
(a) $Mn_2O_7$ (b) $MnO_2$ (c) $MnSO_4$ (d) $Mn_2O_3$

**23.** Which of the following increasing order is not correct as mentioned in the property with it?
(a) $HClO < HClO_2 < HClO_3 < HClO_4$ : (thermal stability)
(b) $HClO_4 < HClO_3 < HClO_2 < HClO$ : (oxidising power)
(c) $F^- < Cl^- < Br^- < I^-$ : (reducing nature)
(d) $HIO_4 < ICl < I_2 < HI$ : (oxidation number of iodine)

**24.** Which of the following statements concerning lanthanoid elements is false?
(a) Lanthanoids are separated from one another by ion-exchange method.
(b) Ionic radii of trivalent lanthanoids steadily increase with increase in the atomic number.
(c) All lanthanoids are highly dense metals.
(d) Most characteristic oxidation state of lanthanoid elements is +3.

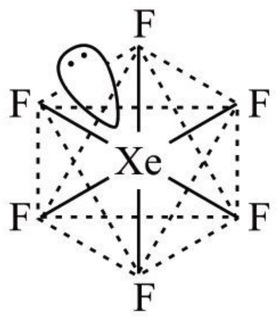
**25.** In $XeF_2$, $XeF_4$ and $XeF_6$, the number of lone pairs on Xe is respectively
(a) 2, 3 and 1 (b) 1, 2 and 3
(c) 4, 1 and 2 (d) 3, 2 and 1

**26.** For $Zn^{2+}$, $Ni^{2+}$, $Cu^{2+}$ and $Cr^{2+}$, which of the following statements is correct?
(a) Only $Zn^{2+}$ is colourless and $Ni^{2+}$, $Cu^{2+}$ and $Cr^{2+}$ are coloured.
(b) All the ions are coloured.
(c) All the ions are colourless.
(d) $Zn^{2+}$ and $Cu^{2+}$ are colourless while $Ni^{2+}$ and $Cr^{2+}$ are coloured.

27. Which of the following has +4 oxidation state?
(a) $H_3PO_4$ (b) $H_3PO_3$
(c) $H_4P_2O_7$ (d) $H_4P_2O_6$

28. The correct order of decreasing second ionisation enthalpy of Ti(22), V(23), Cr(24) and Mn(25) is
(a) Mn > Cr > Ti > V (b) Ti > V > Cr > Mn
(c) Cr > Mn > V > Ti (d) V > Mn > Cr > Ti

29. Which of the following is not correct about xenon hexafluoride?




(a) Xe has an oxidation state of +6.
(b) The hybridisation involved in $XeF_6$ is $sp^3d^3$.
(c) The shape of $XeF_6$ is distorted octahedral and can be represented as above.
(d) On hydrolysis, it gives Xe, HF and $O_2$.

30. The magnetic moment of a divalent ion in aqueous solution with atomic number 25 is
(a) 5.9 B.M. (b) 2.9 B.M. (c) 6.9 B.M. (d) 9.9B.M.

31. Which of the following is a tetrabasic acid?
(a) Hypophosphorous acid
(b) Metaphosphoric acid
(c) Pyrophosphoric acid
(d) Orthophosphoric acid

32. Select the correct option regarding Sc(III), Ti(IV), Pd(II) and Cu(II) ions.
(a) All are paramagnetic.
(b) All are diamagnetic.
(c) Sc(III) and Ti(IV) are paramagnetic while Pd(III) and Cu(II) are diamagnetic.
(d) Sc(III) and Ti(IV) are diamagnetic while Pd(II) and Cu(II) are paramagnetic.

33. Identify the correct sequence of increasing number of π-bonds in structures of the following molecules.
I. $H_2S_2O_6$ II. $H_2SO_3$ III. $H_2S_2O_5$
(a) I, II, III (b) II, III, I
(c) II, I, III (d) I, III, II

34. Gadolinium belongs to 4*f* series. Its atomic number is 64. Which of the following is the correct electronic configuration of gadolinium?
(a) [Xe] $4f^7 5d^1 6s^2$ (b) [Xe] $4f^6 5d^2 6s^2$
(c) [Xe] $4f^8 6d^2$ (d) [Xe] $4f^9 5s^1$

## Assertion & Reason Based MCQs

**For question numbers 35-38, a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.**
(a) If both assertion and reason are correct and reason is the correct explanation of assertion.
(b) If both assertion and reason are correct but reason is not the correct explanation of assertion.
(c) If assertion is correct but reason is wrong.
(d) If assertion is wrong but reason is correct.

35. **Assertion :** White phosphorus is more reactive than red phosphorus.
**Reason :** White phosphorus readily catches fire in air to give dense white fumes of $P_4O_{10}$.

36. **Assertion :** Magnetic moment of $Mn^{2+}$ is less than that of $Cr^{2+}$.
**Reason :** The transition elements exhibit catalytic properties due to their ability to show variable oxidation states.

37. **Assertion :** Acidic character of group 16 hydrides increases from $H_2O$ to $H_2Te$.
**Reason :** Thermal stablility of hydrides decreases down the group.

38. **Assertion :** Zr and Hf occur together in nature and are difficult to separate.
**Reason :** Zr and Hf have identical radii due to lanthanoid contraction.


The same THREE LETTERS will complete these five words.

Can you find the three-letter sequence?

D E N A – – – A T I O N

S A – – – A T E D

S T R U C – – – E

T I N C – – – E

N O M E N C L A – – – E

*Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month.*
*Winners' names will be published in next issue.*

## Match the Columns

**39.** Match the Column I with Column II and mark the appropriate choice.

| Column I | | Column II | |
|---|---|---|---|
| (A) | $H_2SO_3$ | (i) | +6, dibasic |
| (B) | $H_2SO_5$ | (ii) | +5, dibasic |
| (C) | $H_2S_2O_6$ | (iii) | +6, monobasic |
| (D) | $H_2SO_4$ | (iv) | +4, dibasic |

(a) (A) → (i); (B) → (ii); (C) → (iii); (D) → (iv)
(b) (A) → (ii); (B) → (iii); (C) → (i); (D) → (iv)
(c) (A) → (iii); (B) → (iv); (C) → (ii); (D) → (i)
(d) (A) → (iv); (B) → (iii); (C) → (ii); (D) → (i)

**40.** Match the Column I with Column II and mark the appropriate choice.

| Column I | | Column II | |
|---|---|---|---|
| (A) | Element with highest second ionisation enthalpy | (i) | Cr |
| (B) | Element with highest third ionisation enthalpy | (ii) | Cu |
| (C) | $M$ in $M(CO)_6$ is | (iii) | Zn |
| (D) | Element with highest heat of atomisation | (iv) | Ni |

(a) (A) → (iv), (B) → (i), (C) → (ii), (D) → (iii)
(b) (A) → (iii), (B) → (iv), (C) → (ii), (D) → (i)
(c) (A) → (ii), (B) → (iii), (C) → (i), (D) → (iv)
(d) (A) → (i), (B) → (ii), (C) → (iv),(D) → (iii)

## Case Based MCQs

**Case I : Read the passage given below and answer the following questions from 41 to 45.**

Potassium permanganate is prepared from pyrolurite which is an oxide of manganese. Pyrolusite is fused with KOH or $K_2CO_3$ in the presence of air or some oxidating agent. The fused mass is extracted with water and filtered to get a green solution. When chlorine gas is passed through the green solution, the colour of the solution changes to purple due to formation of $KMnO_4$.

**The following questions are multiple choice questions. Choose the most appropriate answer :**

**41.** The formula of pyrolusite is
(a) $Mn_3O_4$ (b) $MnO_2$
(c) MnO (d) $Mn_2O_7$

**42.** The green solution contains
(a) $KMnO_4$ (b) $Mn_3O_4$
(c) $K_2MnO_4$ (d) $K_2MnO_3$

**43.** When chlorine gas is passed through green solution, the oxidation no. of Mn changes from
(a) 6 to 7 (b) 4 to 7
(c) 4 to 6 (d) 7 to 4

**44.** The purple colour of $KMnO_4$ is due
(a) $d$-$d$ transition (b) charge transfer
(c) $p$-$d$ transition (d) $d$-$p$ transition

**45.** The hybrid state of Mn in $KMnO_4$ is
(a) $sp^3d$ (b) $sp^2$
(c) $sd^3$ (d) $sp^3d^2$

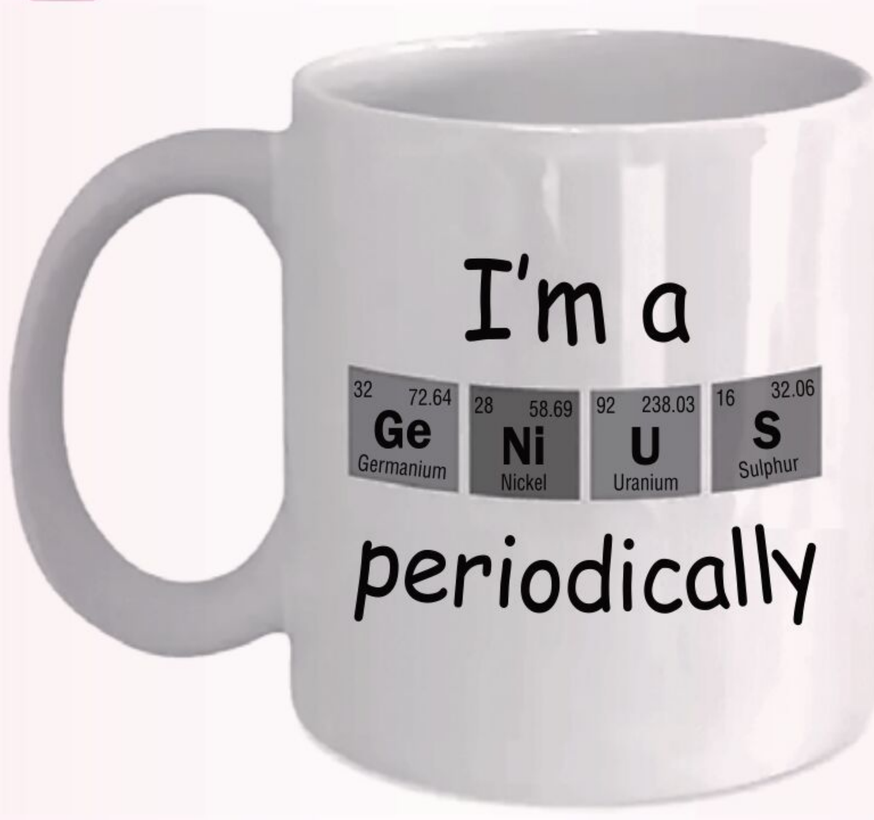
**Case II : Read the passage given below and answer the following questions from 46 to 50.**

Group 17 elements are known as halogens (sea-salt forming). Their general electronic configuration is $[ns^2 np^5]$. Flourine, the first member of the group, differs in several ways from the rest of the group. Halogens are highly reactive elements having strong affinity for hydrogen. All the halogen acids have low boiling points.

**The following questions are multiple choice questions. Choose the most appropriate answer :**

**46.** The oxidising power of halogens is of the order,
(a) $F_2 > I_2 > Br_2 > Cl_2$ (b) $F_2 > Cl_2 > Br_2 > I_2$
(c) $I_2 > Br_2 > Cl_2 > F_2$ (d) $Cl_2 > F_2 > Br_2 > I_2$

### COMIC CAPSULE



**47.** The property of halogens which is not correctly matched is
(a) F > Cl > Br > I : (Ionisation energy)
(b) F > Cl > Br > I : (Electronegativity)
(c) I > Br > Cl > F : (Density)
(d) F > Cl > Br > I : (Electron affinity)

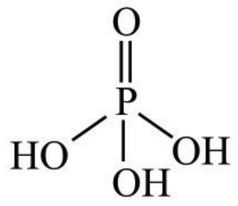
**48.** What is the correct arrangement of the compounds based on their decreasing bond strength?
(a) HF > HCl > HBr > HI
(b) HI > HBr > HCl > HF
(c) HCl > HF > HBr > HI
(d) HF > HBr > HCl > HI

**49.** Mark the correct statement about halogens.
(a) Electron affinity of halogens is of the order, F > Cl > Br > I.
(b) HF is the strongest hydrohalic acid.
(c) $F_2$ has lower bond dissociation energy than $Cl_2$.
(d) All halogens show variable oxidation states.

**50.** The element of group 17 whose half-life is in milliseconds only is
(a) Ts (b) Te
(c) At (d) Og

## SOLUTIONS

**1. (d):**




1 P═O bond
3 P— OH bonds

**2. (c) :** Transition elements exhibit variable oxidation states.

**3. (c) :** $NH_3$ has abnormally high boiling point because of its tendency to form hydrogen bonds. $NH_3$ has higher boiling point than phosphine and then boiling point increases down the group because of increase in size. Hence, the order of boiling point will be

$SbH_3 > NH_3 > AsH_3 > PH_3$

**4. (a)**

**5. (c) :** Noble gases exist as monoatomic gases.

**6. (b)**

**7. (c)**

**8. (a) :** Acidic strength of oxides of transition metals increases with increase in oxidation number.

$\overset{+2}{MnO}, \overset{+8/3}{Mn_3O_4}, \overset{+3}{Mn_2O_3}, \overset{+4}{MnO_2}, \overset{+7}{Mn_2O_7}$

Hence, acidic strength is of the order of

$\underset{\text{Basic}}{MnO} < Mn_3O_4 < \underset{\text{Amphoteric}}{Mn_2O_3} < \underset{\text{Acidic}}{MnO_2} < Mn_2O_7$

**9. (b):** A halate will be formed from halogen and the greenish yellow gas is $Cl_2$. The halate which is used in fireworks and safety matches is $KClO_3$. The reaction involved is

$\underset{\text{Greenish yellow gas}}{3Cl_2} + 6KOH \longrightarrow KClO_3 + 5KCl + 3H_2O$

**10. (d):** $K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \rightarrow K_2SO_4 + \underset{\text{(green)}}{Cr_2(SO_4)_3} + H_2O$

**11. (a)** **12. (d)**

**13. (d):** $3HCl_{(conc.)} + HNO_{3(conc.)} \longrightarrow \underset{(X)}{HNO_3 . 3HCl}$
Aqua regia

Aqua regia is used for dissolving noble metals like gold and platinum. HCl decomposes salts of weaker acids *e.g.*, carbonates, hydrogen carbonates, sulphites, etc.

**14. (a)**

**15. (a) :** $4HNO_3 + P_4O_{10} \rightarrow 4HPO_3 + 2N_2O_5$
Nitrogen pentoxide can be formed by heating $P_4O_{10}$ with conc. nitric acid.

**16. (a)**

**17. (d):** The axial bond pairs suffer more repulsion as compared to equatorial bond pairs.

**18. (c) :** The +4 oxidation state of cerium is also known in solutions.

**19. (a)**

**20. (b):** $2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

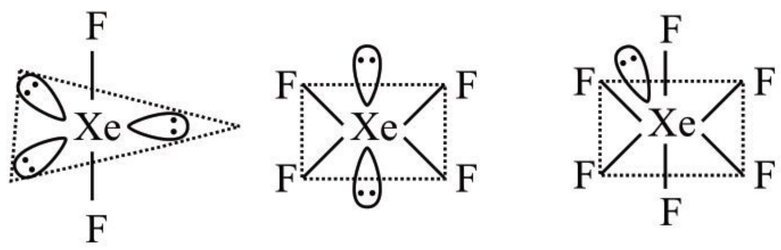
**21. (c) :** Orthophosphoric acid is $H_3PO_4$.

**22. (a) :** $2KMnO_4 + \underset{\text{(conc.)}}{H_2SO_4} \longrightarrow K_2SO_4 + \underset{\text{(Explosive)}}{Mn_2O_7} + H_2O$

**23. (d):** Increasing oxidation number of iodine is in the order : $HI < I_2 < ICl < HIO_4$

**24. (b):** The ionic radii of lanthanoid elements decrease steadily with increase in atomic number due to lanthanoid contraction.

**25. (d):**




*Recipe for Success*

"Always remember, your focus determines your reality."

**26. (a) :** $Zn^{2+}(3d^{10})$ has zero unpaired electron (colourless).
$Ni^{2+}(3d^8)$ has 2 unpaired electrons (coloured).
$Cu^{2+}(3d^9)$ has 1 unpaired electron (coloured).
$Cr^{2+}(3d^4)$ has 4 unpaired electrons (coloured).

**27. (d)** **28. (c)**

**29. (d) :** On hydrolysis of xenon hexafluoride, the products formed are $XeO_3$ and HF.

$$XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$$

**30. (a)** **31. (c)**

**32. (d):** Sc(III) and Ti(IV) do not have unpaired electrons, thus these two are diamagnetic.

**33. (b)** **34. (a)**

**35. (b):** White phosphorus is less stable and more reactive than red phosphorus because of angular strain in the $P_4$ molecule where the angles are only 60°.

**36. (d)**

**37. (b):** The acidic character increases down the group and thermal stability of hydrides decreases down the group due to decrease in bond (H—*E*) dissociation enthalpy down the group.

**38. (a)** **39. (d)** **40. (c)**

**41. (b):** Pyrolusite is $MnO_2$.

**42. (c) :** Green coloured compound is potassium manganate, $K_2MnO_4$.

**43. (a) :** $2K_2MnO_4 + Cl_2 \rightarrow 2KMnO_4 + 2KCl$
The oxidation no. of Mn in $K_2MnO_4$ is +6 while in $KMnO_4$, it is +7.

**44. (b):** The colour of $KMnO_4$ is due to charge transfer as Mn in +7 oxidation state and do not have any *d*-electron.

**45. (c) :** $KMnO_4$ is tetrahedral with Mn in $sd^3$-hybrid state.

**46. (b)**

**47. (d):** Electron affinity of Cl is maximum. The correct trend is Cl > F > Br > I.

**48. (a)**

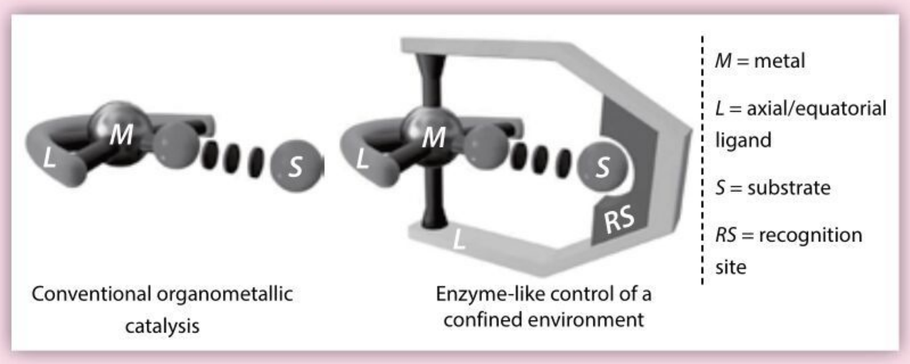
**49. (c) :** $F_2$ has lower bond dissociation energy than $Cl_2$ due to its small size which results in interelectronic repulsions.

**50. (a)**

## CHEMISTRY BULLETIN

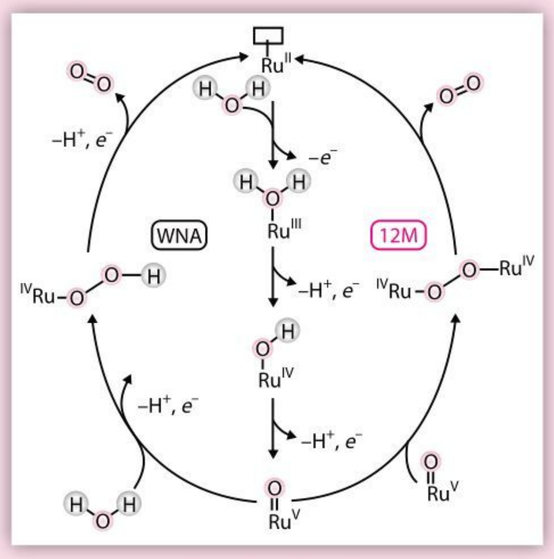
**Designer catalyst with enzyme-like cavity splits water almost as fast as plants!**

Using molecular design, researchers have developed a synthetic water oxidation catalyst with an enzyme-like cavity to speed up the reaction. This unusual catalytic system achieves the challenging oxidative water-splitting reaction at a comparable rate to the photosystems found in photosynthesis.




Water oxidation is a key step in photosynthesis and involves splitting of two water molecules into molecular oxygen and protons using solar energy. While this process is crucial in nature to sustain life, the ability to reproduce this reaction cheaply could help meet humanity's energy needs by creating a steady stream of oxygen and hydrogen. Synthetic mimics of the natural oxygen evolving complex are known, but generally suffer from low catalytic activity or short lifetimes. 'It is very hard to oxidise water,' explains a renewable energy chemist. 'The process requires the transfer of four electrons and so needs a lot of electrochemical or photochemical energy. One of the particularly tricky aspects is ensuring that the catalyst isn't just "burnt up" by these demanding conditions.'

Ruthenium metal centres have shown promise as water oxidation catalysts, but their performance is strongly dependent on the mechanistic pathway of the oxygen-oxygen bond forming reaction. Altering pH can promote preorganisation of water molecules around the metal centre, favouring the water nucleophilic attack mechanism and resulting in enhanced catalytic performance. However, this has been rarely used in catalyst design.




Researchers in Germany have now developed a pH-sensitive macrocyclic ruthenium system, able to form an enzyme-like cavity around the metal centre under acidic conditions. 'Traditional transition metal catalyst design has focused on the directly bound ligands to tune electronic properties and the structural environment,' says an organic chemist. 'Here we have embedded the ruthenium catalyst in a macrocycle to make use of the functional groups positioned on the opposite side of the pocket.' Extensive mechanistic analysis revealed that the macrocycle acts like a pH-controlled door, closing to form a small molecular cleft under acidic conditions. At low pH, the basic groups on the backbone of the macrocycle become protonated, resulting in the slight rotation of the axial ligands. This creates an enclosed enzyme-like cavity in which hydrogen bonds preorganise molecules of water in front of the reactive ruthenium centre, enabling rapid oxidation.

# Are you ready for Olympiads?

## LEVEL II

SCIENCE OLYMPIAD FOUNDATION | SOF NATIONAL SCIENCE OLYMPIAD

## CLASS XI

### SYLLABUS*

**Section – 1 :** *Physics* : Units and Measurements, Mechanics, Properties of Matter, Heat and Thermodynamics, Oscillations, Waves.

*Chemistry* : Some Basic Concepts of Chemistry, Structure of Atom, Classification of Elements and Periodicity in Properties, Chemical Bonding and Molecular Structure, States of Matter, Thermodynamics, Equilibrium, Redox Reactions, Hydrogen, The *s*-Block Elements, The *p*-Block Elements (Groups 13 and 14), Organic Chemistry - Some Basic Principles and Techniques, Hydrocarbons, Environmental Chemistry.

**Section – 2 :** Higher Order Thinking Questions - Syllabus as per Section – 1.

Total Questions : 50 Time : 1 hr.

| PATTERN & MARKING SCHEME | | | |
|---|---|---|---|
| **Section** | **(1) Physics & Chemistry** | **(2) Achievers Section** | **(3) Mathematics or Biology** |
| **No. of Questions** | **25** | **5** | **20** |
| **Marks per Ques.** | **1** | **3** | **1** |

**Section – 3 :** Sets, Relations and Functions, Principle of Mathematical Induction, Logarithms, Complex Numbers & Quadratic Equations, Linear Inequations, Sequences and Series, Trigonometry, Straight Lines, Conic Sections, Permutations and Combinations, Binomial Theorem, Statistics, Mathematical Reasoning, Limits and Derivatives, Probability, Introduction to 3-D Geometry.

**OR**

**Section – 3 :** Diversity in the Living World, Structural Organisation in Plants and Animals, Cell : Structure and Functions, Plant Physiology, Human Physiology.

### Practice Questions

**1.** At 300 K, $N_2$ and $H_2$ are mixed and the reaction, $N_2 + 3H_2 \rightarrow 2NH_3$ is carried out. The standard free energy of formation of $NH_3$ is –16.4 kJ/mol. The partial pressures of $N_2$, $H_2$ and $NH_3$ become 50 bar, 2 bar and 200 bar, respectively after one hour of mixing. What will be free energy at this stage of the reaction?

A. $+5.02\ kJ\ mol^{-1}$ B. $-5.02\ kJ\ mol^{-1}$
C. $-27.88\ kJ\ mol^{-1}$ D. $+27.88\ kJ\ mol^{-1}$

**2.** Select the mixture that will have the lowest pH at 298 K?

A. 10 mL 0.05 N $CH_3COOH$ + 5 mL 0.1 N $NH_4OH$
B. 5 mL 0.2 N $NH_4Cl$ + 5 mL 0.2 N $NH_4OH$
C. 5 mL 0.1 N $CH_3COOH$ + 10 mL 0.05 N $CH_3COONa$
D. 5 mL 0.1 N $CH_3COOH$ + 5 mL 0.1 N NaOH

**3.** Consider the following balanced chemical reaction,
$IO_3^- + aI^- + bH^+ \rightarrow cH_2O + dI_2$
*a, b, c* and *d* respectively can be assigned as

A. 5, 6, 3, 3 B. 5, 3, 6, 3
C. 3, 5, 3, 6 D. 5, 6, 5, 5

**4.** Mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will (considering $\frac{1}{6}$ in place of $\frac{1}{12}$)

A. decrease to half
B. increase two fold
C. remain unchanged
D. be a function of the molecular mass of the substance.

**5.** The correct order of ionic radii is

A. $N^{3-} > O^{2-} > F^- > Na^+$
B. $N^{3-} > Na^+ > O^{2-} > F^-$
C. $Na^+ > O^{2-} > N^{3-} > F^-$
D. $O^{2-} > F^- > Na^+ > N^{3-}$

**6.** Consider the following statements and select the incorrect one.

A. Hybridisation is the mixing of atomic orbitals and their simultaneous combination into molecular orbitals.
B. $sp^2$ hybrid orbitals are formed from two *p*-atomic orbitals and one *s*-atomic orbital.
C. $dsp^2$ hybrid orbitals are all at 90° to one another.
D. $d^2sp^3$ hybrid orbitals are directed towards the corners of a regular octahedron.

**7.** An allyl isocyanide has

A. 9 σ and 4 π bonds
B. 8 σ and 5 π bonds
C. 9 σ, 3 π and 2 non-bonded electrons
D. 8 σ, 3 π and 4 non-bonded electrons.

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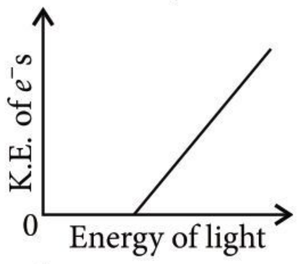
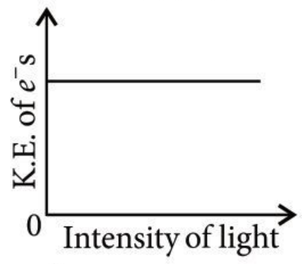
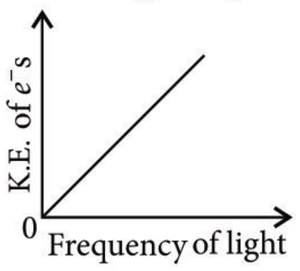
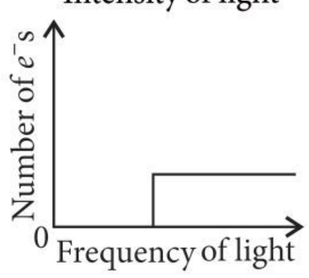
**8.** The relationship between incident light and the electron ejected from metal surface is not represented by which of the following graphs?

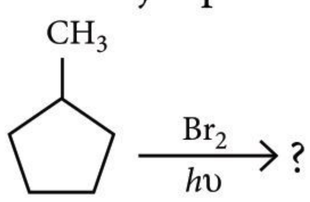
A. 

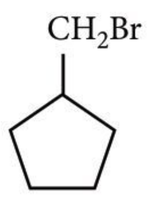

B. 

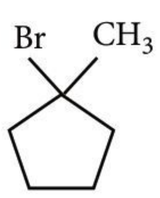

C. 

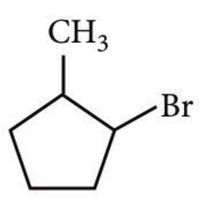

D. 

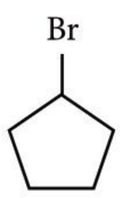

**9.** The major product formed in following reaction is




A. 


B. 


C. 


D. 


**10.** Select the correct order of basicity from weak to strong for the following intermediates.

(i) 

(ii) $H_2C{=}CH{-}\bar{C}H_2$

(iii) $HC{\equiv}\bar{C}$ (iv) $\bar{C}H_3$ (v) $\bar{C}N$

A. (v) < (iii) < (ii) < (iv) < (i)
B. (iii) < (i) < (ii) < (iv) < (v)
C. (v) < (i) < (iv) < (ii) < (iii)
D. (iii) < (iv) < (ii) < (i) < (v)

**11.** Match column I with column II and select the correct option.

| | Column I (Molecule/Ion) | | Column II (Molecular geometry) |
|---|---|---|---|
| I | $HgCl_2$ | 1. | Tetrahedral |
| II | $NH_4^+$ | 2. | Trigonal bipyramidal |
| III | $SF_6$ | 3. | Linear |
| IV | $PCl_5$ | 4. | Octahedral |

| | I | II | III | IV |
|---|---|---|---|---|
| A. | 4 | 3 | 2 | 1 |
| B. | 3 | 1 | 4 | 2 |
| C. | 3 | 2 | 1 | 4 |
| D. | 2 | 3 | 4 | 1 |

**12.** Which of the following equations give ionic product of water?

(i) $NH_{3(aq)} + H_2O \rightleftharpoons NH_{4(aq)}^+ + OH_{(aq)}^-$
(ii) $NH_{4(aq)}^+ + H_2O \rightleftharpoons H_3O^+ + NH_{3(aq)}$
(iii) $NH_{2(aq)}^- + H_2O \rightleftharpoons NH_{3(aq)} + OH^-$
(iv) $NH_{3(aq)} + OH_{(aq)}^- \rightleftharpoons NH_{2(aq)}^- + H_2O$

A. (ii) and (iii) B. (iii) and (iv)
C. (i) and (ii) D. (iii) and (i)

**13.** An oxide of iodine (At. mass of I = 127) contains 25.4 g of iodine and 8 g of oxygen. Its formula could be

A. $I_2O_3$ B. $I_2O$ C. $I_2O_5$ D. $I_2O_9$

**14.** Consider the following ionisation enthalpies of two elements '*M*' and '*N*':

| Element | Ionisation enthalpy (kJ/mol) | | |
|---|---|---|---|
| | 1st | 2nd | 3rd |
| *M* | 899 | 1757 | 14847 |
| *N* | 737 | 1450 | 7731 |

Which of the following statements is correct?

A. Both '*M*' and '*N*' belong to group-2 where '*M*' comes below '*N*'.
B. Both '*M*' and '*N*' belong to group-2 where '*N*' comes below '*M*'.
C. Both '*M*' and '*N*' belong to group-1 where '*N*' comes below '*M*'.
D. Both '*M*' and '*N*' belong to group-1 where '*M*' comes below '*N*'.

**15.** Select the correct statement.

A. Quantum numbers (*n*, *l*, *m*, *s*) are obtained arbitrarily.

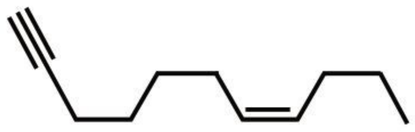
B. All the quantum numbers (*n, l, m, s*) for any pair of electrons in an atom can be identical under special circumstances.
C. All the quantum numbers (*n, l, m, s*) may not be required to describe an electron of an atom completely.
D. All the quantum numbers (*n, l, m, s*) are required to describe an electron of an atom completely.

## ACHIEVERS SECTION

**16.** The major product formed in the following reaction is


A. 

B. 

C. 

D. 

**17.** Match Column I with Column II and select the correct option.

| | Column I (Species) | | Column II (Hybrid Orbitals) |
|---|---|---|---|
| P. | $SF_4$ | (i) | $sp^3d^2$ |
| Q. | $IF_5$ | (ii) | $d^2sp^3$ |
| R. | $NO_2^+$ | (iii) | $sp^3d$ |
| S. | $NH_4^+$ | (iv) | $sp^3$ |
| | | (v) | $sp$ |

A. P – (iii), Q – (i), R – (v) and S – (iv)
B. P – (ii), Q – (i), R – (iv) and S – (v)
C. P – (iv), Q – (iii), R – (i) and S – (v)
D. P – (i), Q – (ii), R – (v) and S – (iii)

**18.** The standard state Gibbs free energies of formation of $C_{(graphite)}$ and $C_{(diamond)}$ at $T = 298$ K are
$\Delta_f G°[C_{(graphite)}] = 0$ kJ mol$^{-1}$;
$\Delta_f G°[C_{(diamond)}] = 2.9$ kJ mol$^{-1}$
By standard state, it means that the pressure should be 1 bar, and substance should be pure at a given temperature. In the conversion of graphite to diamond, the volume gets reduced by $2 \times 10^{-6}$ m$^3$ mol$^{-1}$. If $C_{(graphite)}$ is converted to $C_{(diamond)}$ isothermally at $T = 298$ K, the pressure at which $C_{(graphite)}$ is in equilibrium with $C_{(diamond)}$, is
[Useful information: 1 J = 1 kg m$^2$ s$^{-2}$; 1 Pa = 1 kg m$^{-1}$ s$^{-2}$; 1 bar = $10^5$ Pa]
A. 29001 bar B. 58001 bar
C. 14500 bar D. 1450 bar

**19.** Solid $AgNO_3$ is gradually added to the solution having 0.1 M in $Cl^-$ and 0.001 M in $CrO_4^{2-}$. Assuming there is no change in volume after addition.
[Given: $K_{sp}(AgCl) = 1.7 \times 10^{-10}$ M$^2$ and $K_{sp}(Ag_2CrO_4) = 1.9 \times 10^{-12}$ M$^3$].
Select correct statement from the following.
A. AgCl will precipitate first as the amount of $Ag^+$ needed to precipitate is low.
B. $Ag_2CrO_4$ precipitates first because the amount of $Ag^+$ needed is low.
C. AgCl precipitates first because its $K_{sp}$ is high.
D. $Ag_2CrO_4$ precipitates first as its $K_{sp}$ is low.

**20.** Consider the following statements regarding the interpretation of the atomic orbitals and select the correct one.
(i) An electron in an orbital of high angular momentum stays away from the nucleus than an electron in the orbital of lower angular momentum.
(ii) For a given value of the principal quantum number, the size of the orbit is inversely proportional to the azimuthal quantum number.
(iii) According to wave mechanics, the ground state angular momentum is equal to $h/2\pi$.
(iv) The plot of $\psi$ *vs* $r$ for various azimuthal quantum numbers, shows peak shifting towards higher $r$ value.
A. (i) and (iv) only B. (i) and (iii) only
C. (i) and (ii) only D. (ii) and (iii) only

Darken your choice with HB Pencil

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 5. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 9. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 13. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 17. | Ⓐ | Ⓑ | Ⓒ | Ⓓ |
| 2. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 6. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 10. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 14. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 18. | Ⓐ | Ⓑ | Ⓒ | Ⓓ |
| 3. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 7. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 11. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 15. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 19. | Ⓐ | Ⓑ | Ⓒ | Ⓓ |
| 4. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 8. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 12. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 16. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 20. | Ⓐ | Ⓑ | Ⓒ | Ⓓ |

## SOLUTIONS

**1. (C) :** $\Delta G = \Delta G^\circ + RT \ln \left[ \frac{(p_{NH_3})^2}{(p_{N_2})(p_{H_2})^3} \right]$

$-16.4 \text{ kJ mol}^{-1} = \Delta G^\circ + 8.3145 \times 300 \ln \left[ \frac{(200)^2}{(50) \times (2)^3} \right]$

$\Delta G^\circ = -27.88 \text{ kJ mol}^{-1}$

**2. (C)**

**3. (A) :** The complete balanced equation is

$IO_3^- + 5I^- + 6H^+ \rightarrow 3H_2O + 3I_2$

**4. (A) :** 1 atomic mass unit on the scale of 1/6 of C–12 = 2 amu on the scale of 1/12 of C–12.

Now, atomic mass of an element

$$= \frac{\text{Mass of one atom of the element}}{1 \text{ amu (Here on the scale of } \frac{1}{6} \text{ of C-12)}}$$

$$= \frac{\text{Mass of one atom of the element}}{2 \text{ amu (Here on the scale of } \frac{1}{12} \text{ of C-12)}}$$

$\therefore$ Numerically, the mass of a substance will become half of the normal scale.

**5. (A)**

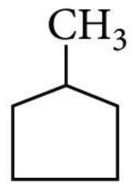
**6. (C) :** In $dsp^2$ hybrid orbitals, two adjacent orbitals are at 90° whereas opposite hybrid orbitals are at 180°.

**7. (C) :** $CH_2 = CH - CH_2 - N \equiv C$

There are 9σ, 3π and 2 non-bonded electrons.

**8. (C)**

**9. (B) :** $Br_2 \xrightarrow{h\upsilon} 2\dot{B}r$

This will react with  to give the most stable 3° free radical.

**10. (A) :** $\text{Basicity} \propto \frac{1}{\text{Electronegativity}}$

**11. (B)** **12. (C)**

**13. (C) :** $\text{Moles of I} = \frac{\text{Given mass}}{\text{Molar mass}} = \frac{25.4}{127} = 0.2 \text{ mol}$

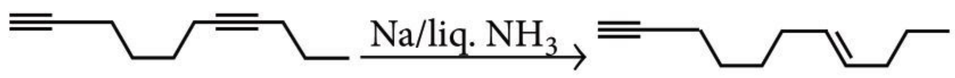
$\text{Moles of O} = \frac{8}{16} = \frac{1}{2} = 0.5 \text{ mol}$

Ratio of I : O is 2:5. Thus, molecular formula will be $I_2O_5$.

**14. (B) :** As the third ionisation energy of *M* and *N* are very high as compared to corresponding second ionisation energy, thus, there must be two electrons in their valence shells. Hence, elements *M* and *N* belong to group-2. On going down the group, the atomic size increases, so force of attraction between valence electron and nucleus decreases. Hence, ionisation energy decreases. Thus, '*N*' comes below '*M*'.

**15. (D)**

**16. (B)**




**17. (A)**

**18. (C) :** $C_{(graphite)} \longrightarrow C_{(diamond)}$ (Isothermally)

$\Delta_r G^\circ = \Delta G^\circ_{(diamond)} - \Delta G^\circ_{(graphite)}$

$= 2.9 - 0 = 2.9 \text{ kJ mol}^{-1}$

Gibbs free energy is the maximum useful work, then

$-\Delta G = w_{max} = P\Delta V$ ; $-2.9 \times 10^3 = -P \times 2 \times 10^{-6}$

$P = \frac{2.9 \times 10^3}{2 \times 10^{-6}} = 1.45 \times 10^4 \text{ bar} = 14500 \text{ bar}$

**19. (A) :** (i) Concentration of $Ag^+$ required for precipitation of AgCl.

$K_{sp}(AgCl) = [Ag^+][Cl^-]$

$1.7 \times 10^{-10} = [Ag^+][0.1]$

$[Ag^+] = 1.7 \times 10^{-9} M$

(ii) Concentration of $Ag^+$ required for precipitation of $Ag_2CrO_4$.

$K_{sp}(Ag_2CrO_4) = [Ag^+]^2 [CrO_4^{2-}]$

$1.9 \times 10^{-12} = [Ag^+]^2 (0.001)$

$[Ag^+] = \sqrt{1.9 \times 10^{-9}} = \sqrt{19} \times 10^{-5}$

Amount of $Ag^+$ required to precipitate is low for $Cl^-$. So, AgCl gets precipitated first.

**20. (A)**

*For other sections/subjects please refer to Physics For You and Biology Today*

### TRIO

### ANSWERS NOVEMBER 2022

The three letter word is **E R M**.

T H **E R M** O S T A T

I S O T H **E R M**

T H **E R M** O M E T E R

G **E R M** A N I U M

E X O T H **E R M** I C

*Winners : Debosmita Santra, Gagan Marer and Ananya Goswami*

# Are you ready for Olympiads?

## LEVEL II

SCIENCE OLYMPIAD FOUNDATION | SOF NATIONAL SCIENCE OLYMPIAD

## CLASS XII

### SYLLABUS*

**Section – 1 :** *Physics* : Electricity and Magnetism, Electromagnetic Induction, Alternating current, Electromagnetic waves, Optics, Modern Physics, Semiconductor Electronics, Communication Systems.

*Chemistry* : Solid State, Solutions, Electrochemistry, Chemical Kinetics, Surface Chemistry, General Principles and Processes of Isolation of Elements, *p*-Block Elements (Group 15 to 18), *d*- & *f*-Block Elements, Coordination Compounds, Haloalkanes and Haloarenes, Alcohols, Phenols and Ethers, Aldehydes, Ketones and Carboxylic Acids, Amines, Biomolecules, Polymers, Chemistry in Everyday Life.

Total Questions : 50 Time : 1 hr.

| PATTERN & MARKING SCHEME | | | |
|---|---|---|---|
| **Section** | **(1) Physics & Chemistry** | **(2) Achievers Section** | **(3) Mathematics or Biology** |
| **No. of Questions** | **25** | **5** | **20** |
| **Marks per Ques.** | **1** | **3** | **1** |

**Section – 2 :** Higher Order Thinking Questions - Syllabus as per Section – 1.

**Section – 3 :** Relations and Functions, Inverse Trigonometric Functions, Matrices and Determinants, Continuity and Differentiability, Application of Derivatives, Integrals, Application of Integrals, Differential Equations, Vector Algebra, Three Dimensional Geometry, Probability, Linear Programming.

**OR**

**Section – 3 :** Reproduction, Genetics and Evolution, Biology in Human Welfare, Biotechnology, Ecology.

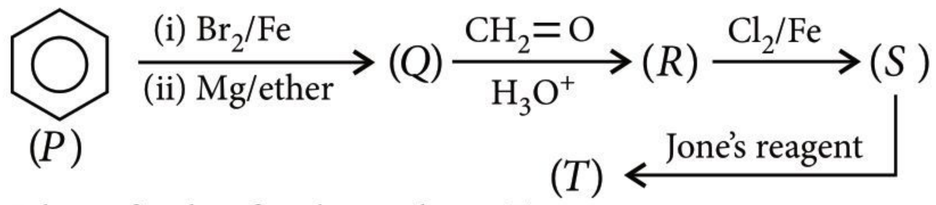
## Practice Questions

**1.** The mathematical relation between degree of dissociation ($\alpha$) of a weak electrolyte, $A_xB_y$ and van't Hoff factor ($i$) is

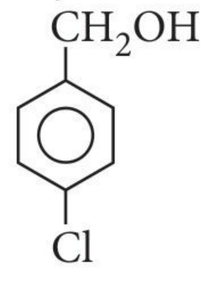
A. $\alpha = \dfrac{i-1}{(x+y-1)}$ B. $\alpha = \dfrac{i-1}{(x+y+1)}$

C. $\alpha = \dfrac{(x+y-1)}{i-1}$ D. $\alpha = \dfrac{(x+y+1)}{i-1}$

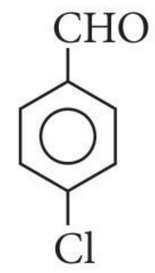
**2.** Consider the following sequence of reactions :

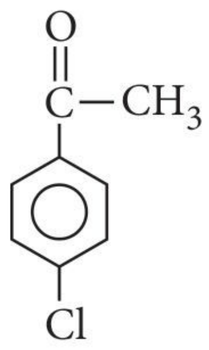



Identify the final product *T*.

A. 


B. 


C. 

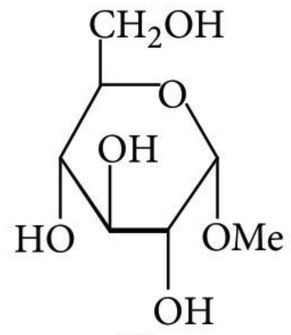

D. 


**3.** The ion which has zero CFSE in octahedral field is

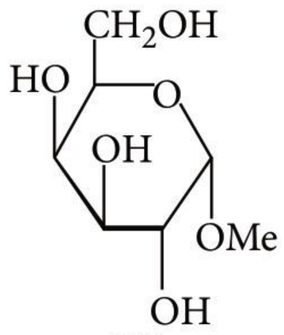
A. $Cr^{3+}$ (high spin) B. $Co^{2+}$ (low spin)

C. $Fe^{3+}$ (low spin) C. $Fe^{3+}$ (high spin).

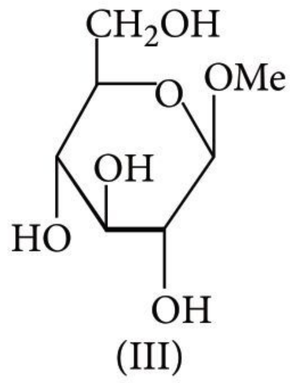
**4.** Select the correct set of stereochemical relationship amongst the following monosaccharides.



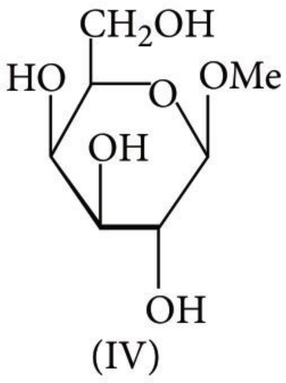

(I)




(II)




(III)




(IV)

A. (I) and (III) are epimers; (II) and (IV) are anomers.

B. (I) and (II) are epimers ; (III) and (IV) are anomers.

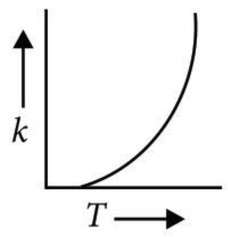
C. (I) and (III) are anomers; (I) and (II) are epimers.

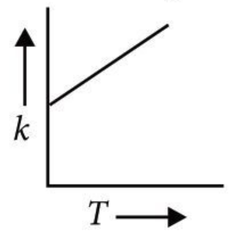


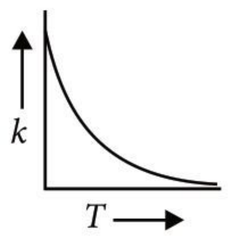
*For latest updates visit www.sofworld.org

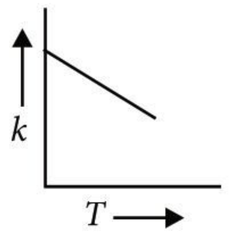
D. (I) and (II) are anomers; (III) and (IV) are epimers.

**5.** Various plots showing the variation of the rate constant ($k$) with temperature ($T$) are shown below. Select the plot that follows Arrhenius equation.

A. 

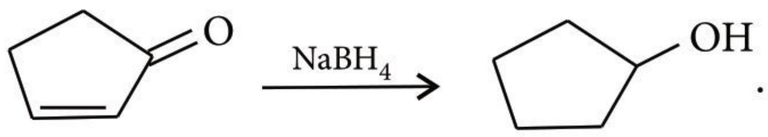

B. 


C. 


D. 


**6.** In nitroprusside ion, the iron and NO exist as $Fe^{II}$ and $NO^{+}$ rather than $Fe^{III}$ and NO. These forms can be differentiated by

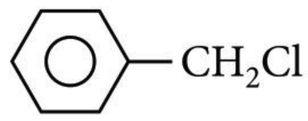
A. estimating the concentration of iron
B. measuring the concentration of CN
C. measuring the solid state magnetic moment
D. thermally decomposing the compound.

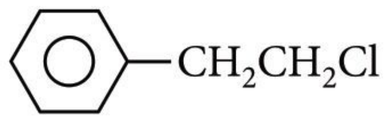
**7.** 


The yield of this reaction is

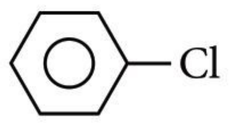
A. 100% B. 10% C. 50% D. 0%

**8.** Which one of the following chlorohydrocarbon readily undergoes solvolysis?

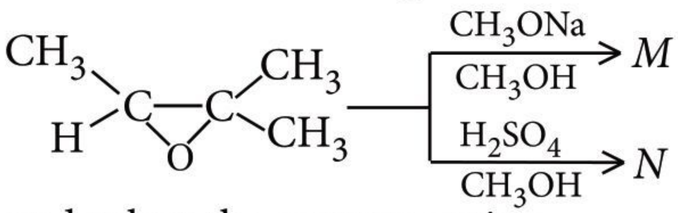
A. 


C. 


C. $CH_2=CHCl$

D. 


**9.** Consider the following reactions,




and select the correct option.

A. $M$ and $N$ both are 3-methoxy-2-methyl -2-butanol.
B. $M$ and $N$ both are 3-methoxy-3-methyl-2-butanol.
C. $M$ is 3-methoxy-3-methyl-2-butanol and $N$ is 3-methoxy-2-methyl-2-butanol.
D. $M$ is 3-methoxy-2-methyl-2-butanol and $N$ is 3-methoxy-3-methyl-2-butanol.

**10.** Anhydrous ferric chloride can be prepared by

A. heating hydrated ferric chloride at a high temperature in a stream of air
B. heating metallic iron in a stream of dry chlorine gas
C. reaction of metallic iron with concentrated hydrochloric acid
D. reaction of metallic iron with dilute nitric acid.

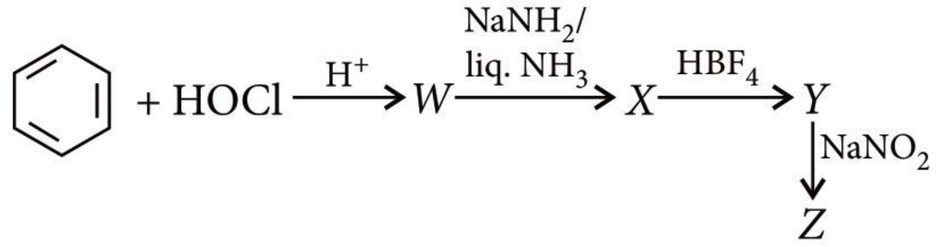
**11.** During depression of freezing point in a solution, which of the following are in equilibrium?

A. liquid solvent, solid solvent
B. liquid solvent, solid solute
C. liquid solute, solid solute
D. solid solute, solid solvent.

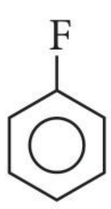
**12.** An electric current is passed through an aqueous solution of a mixture of alanine (isoelectric point 6.0), glutamic acid (3.2) and arginine (10.7) buffered at pH 6. What will the fate of the three acids?

A. All these remain uniformly distributed in solution.
B. Glutamic acid migrates to anode at pH 6. Arginine present as a cation and migrates to the cathode. Alanine as a dipolar ion remains uniformly distributed in solution.
C. Glutamic acid will migrate to cathode while others remain uniformly distributed in solution.
D. All three move to anode.

**13.** In the following sequence of reactions :



What will be the final product *Z*.

A. 
B. 
C. 
D. 

**14.** Conductivity (unit Siemen, S) is directly proportional to area of the vessel and the concentration of the solution in it and is inversely proportional to the length of the vessel. What will be the unit of the constant of proportionality?

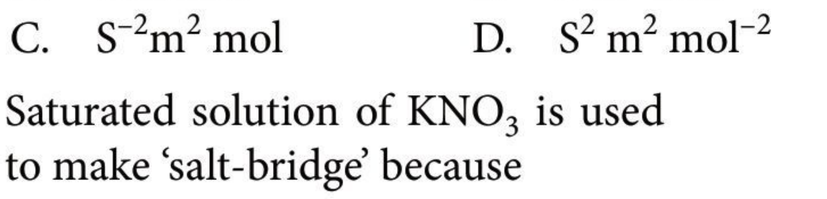
A. $S\ m\ mol^{-1}$ B. $S\ m^2\ mol^{-1}$
C. $S^{-2}m^2\ mol$ D. $S^2\ m^2\ mol^{-2}$

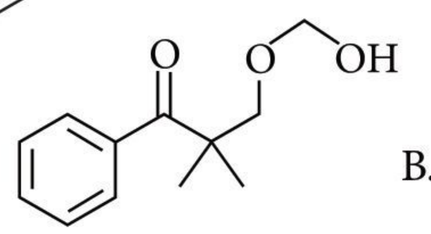
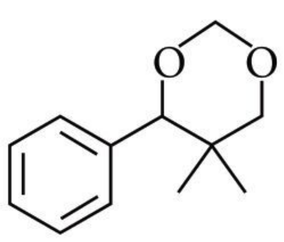
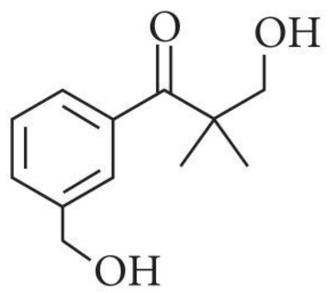
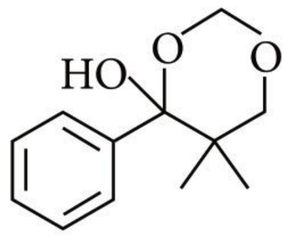
**15.** Saturated solution of $KNO_3$ is used to make 'salt-bridge' because

A. velocity of $K^+$ is larger than that of $NO_3^-$
B. velocity of $NO_3^-$ is smaller than that of $K^+$
C. velocities of both $K^+$ and $NO_3^-$ are nearly the same
D. $KNO_3$ is highly soluble in water.

## ACHIEVERS SECTION

**16.** The major product of the following reaction sequence is

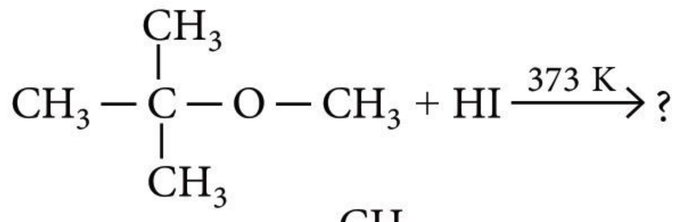


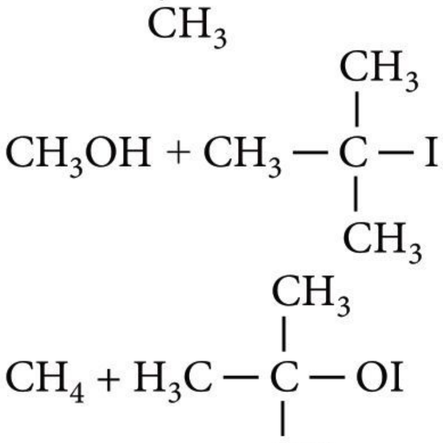

A. 
B. 
C. 
D. 

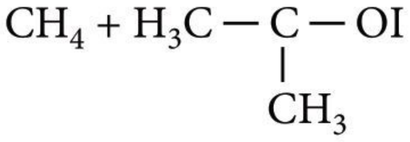
**17.** The correct order of intensity of colours of the compounds is

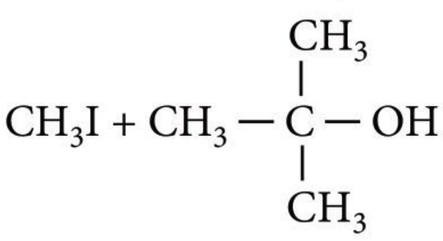
A. $[Ni(H_2O)_6]^{2+} > [NiCl_4]^{2-} > [Ni(CN)_4]^{2-}$
B. $[NiCl_4]^{2-} > [Ni(CN)_4]^{2-} > [Ni(H_2O)_6]^{2+}$
C. $[NiCl_4]^{2-} > [Ni(H_2O)_6]^{2+} > [Ni(CN)_4]^{2-}$
D. $[Ni(CN)_4]^{2-} > [NiCl_4]^{2-} > [Ni(H_2O)_6]^{2+}$

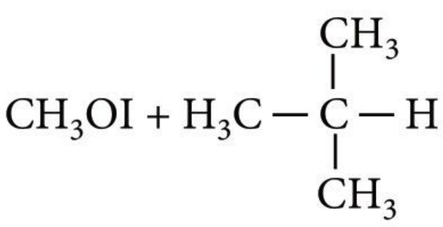
**18.** The products formed during the following reaction are




A. 


B. 


C. 


D. 


**19.** The correct statements about $Cr^{2+}$ and $Mn^{3+}$ are
[Atomic numbers of Cr = 24 and Mn = 25]

I. $Cr^{2+}$ is a reducing agent.
II. $Mn^{3+}$ is an oxidizing agent.
III. Both $Cr^{2+}$ and $Mn^{3+}$ exhibit $d^4$ electronic configuration.
IV. When $Cr^{2+}$ is used as a reducing agent, the chromium ion attains $d^5$ electronic configuration.

A. I, II and III only B. III and IV only
C. I, II and IV only D. II and IV only

**20.** For a first order reaction, select the correct statements.

I. The degree of dissociation is equal to $(1 - e^{-kt})$.
II. A plot of reciprocal of concentration of the reactant *vs* time gives a straight line.
III. The time taken for the completion of 75% reaction is thrice the $t_{1/2}$ of the reaction.
IV. The pre-exponential factor in the Arrhenius equation has the dimension of time, $T^{-1}$.

A. I and IV only B. II and III only
C. I and III only D. II and IV only

Darken your choice with HB Pencil

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 5. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 9. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 13. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 17. | Ⓐ | Ⓑ | Ⓒ | Ⓓ |
| 2. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 6. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 10. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 14. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 18. | Ⓐ | Ⓑ | Ⓒ | Ⓓ |
| 3. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 7. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 11. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 15. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 19. | Ⓐ | Ⓑ | Ⓒ | Ⓓ |
| 4. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 8. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 12. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 16. | Ⓐ | Ⓑ | Ⓒ | Ⓓ | 20. | Ⓐ | Ⓑ | Ⓒ | Ⓓ |

## SOLUTIONS

**1. (A) :**

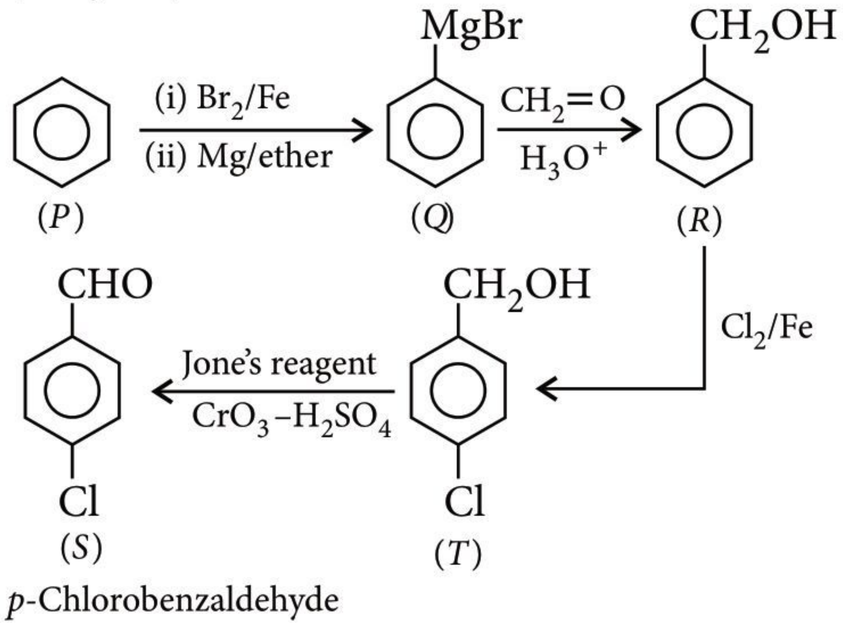
$$\underset{\text{initial moles}}{A_xB_y} \rightarrow \underset{0}{xA^{y+}} + \underset{0}{yB^{x-}}$$

$$\underset{\text{final moles}}{1-\alpha} \qquad x\alpha \qquad y\alpha$$

$$i = \frac{1-\alpha+x\alpha+y\alpha}{1} = 1 + \alpha(x + y - 1)$$

$$\therefore \quad \alpha = \frac{i-1}{(x+y-1)}$$

**2. (C) :**




*p*-Chlorobenzaldehyde

**3. (D) :** $Cr^{3+}$ (high spin) $\Rightarrow t_{2g}^3 e_g^0$;

CFSE = $-0.4 \times 3 = -1.2\ \Delta_o$

$Co^{2+}$ (low spin) $\Rightarrow t_{2g}^6 e_g^1$;

CFSE = $-0.4 \times 6 + 0.6 \times 1 = -1.8\ \Delta_o$

$Fe^{3+}$ (low spin) $\Rightarrow t_{2g}^5 e_g^0$;

CFSE = $-0.4 \times 5 = -2.00\ \Delta_o$

$Fe^{3+}$ (high spin) $\Rightarrow t_{2g}^3 e_g^2$;

CFSE = $-0.4 \times 3 + 0.6 \times 2 = 0.0\ \Delta_o$

**4. (C) :** (I) and (III) differ in configuration at $C_1$ and hence are anomers while (I) and (II) differ in configuration at $C_4$ and hence are epimers.

**5. (A)**

**6. (C) :** Magnetic moment μ is given by

$\mu = \sqrt{n(n+2)}$ B.M.

Where, $n$ is the number of unpaired electrons.

Number of unpaired electrons in various species are

$Fe^{2+}$: It is $3d^6$ *i.e.* 4 unpaired electrons

$Fe^{3+}$: It is $3d^5$ *i.e.* 5 unpaired electrons

$^+NO$ or $^+\underset{\times\times}{N}{=}\ddot{O}:$, in this all the electrons are paired.

NO or $\overset{\times}{\underset{\times}{}}N\overset{\times\bullet\bullet}{\equiv}O:$, we have a three electron bond so it has an odd (unpaired electron). *i.e.* $n = 1$

Since, they (*i.e.* $^+NO$ and NO) have different number of unpaired electrons so they can be differentiated by the measurement of the solid state magnetic moment of nitroprusside ion.

**7. (D) :** $NaBH_4$ cannot reduce carbon-carbon double bond which is conjugated with carbon-oxygen double bond.

**8. (A)** **9. (D)**

**10. (B) :** $\underset{\text{(Dry)}}{2Fe + 3Cl_2} \longrightarrow \underset{\text{(Anhydrous)}}{2FeCl_3}$

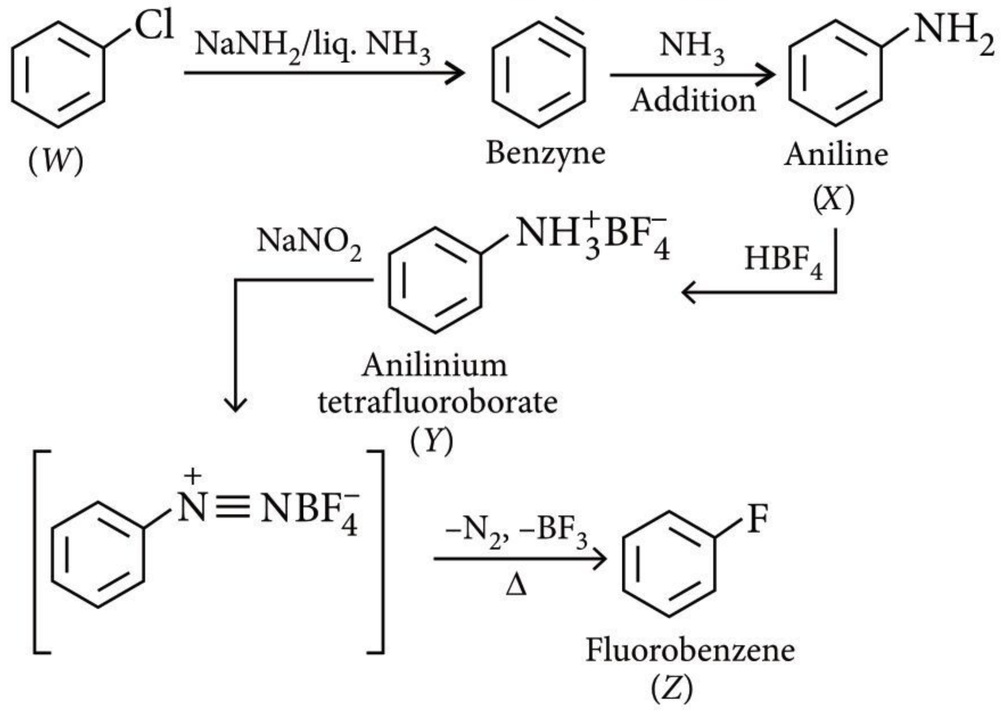
**11. (A)**

**12. (B) :** At pH = 6, glutamic acid exists as a dianionic species and migrates to anode while arginine exists as cationic species and moves to cathode. Alanine does not migrate to any electrode at its isoelectric point.

**13. (D) :** At first, generation of electrophile (chloronium ion, $Cl^+$) takes place which attacks on benzene.

$$\underset{\text{Benzene}}{C_6H_6} + Cl^+ \xrightarrow{-H^+} \underset{\substack{\text{Chlorobenzene}\\(W)}}{C_6H_5Cl}$$

*A* on treatment with $NaNH_2$/liq. $NH_3$ gives aniline (*B*).




**14. (B) :** According to the given information.

$$\text{Conductivity} \propto \frac{\text{Area} \times \text{Concentration}}{\text{length of vessel}}$$

$$\text{Conductivity} = K \times \frac{\text{Area} \times \text{Concentration}}{\text{length of vessel}}$$

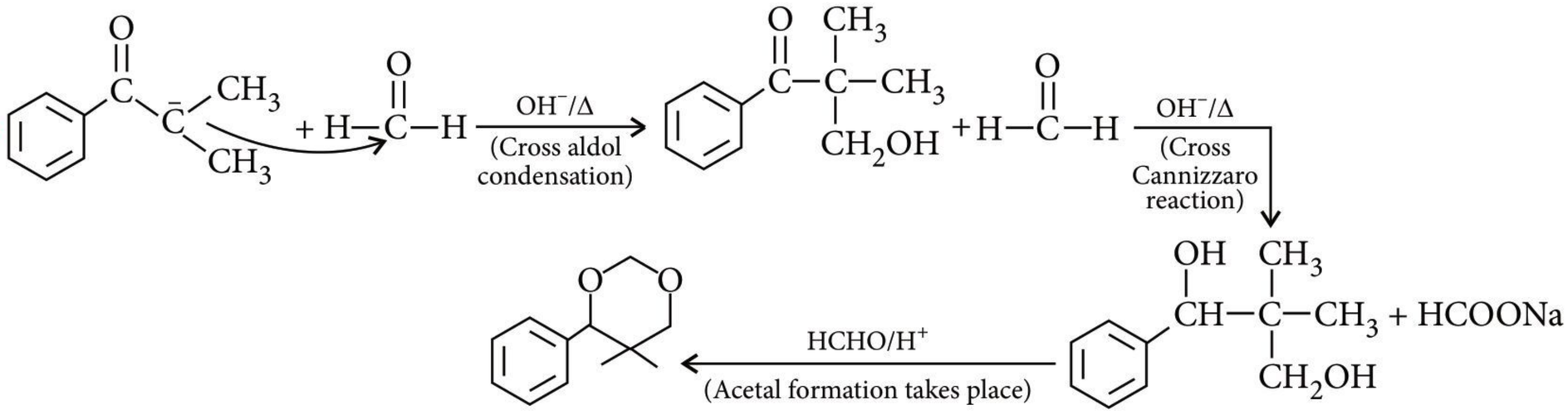
$$\text{Unit of constant, } K = \frac{\text{S. m}}{\text{m}^2 \times \text{mol m}^{-3}} = \text{S m}^2 \text{ mol}^{-1}$$

**15. (C)**

**MONTHLY TEST DRIVE CLASS XII ANSWER KEY**

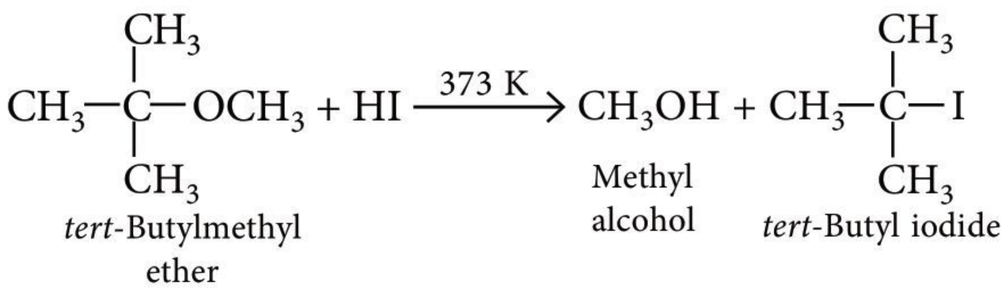
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | (c) | **2.** | (b) | **3.** | (c) | **4.** | (a) | **5.** | (a) |
| **6.** | (a) | **7.** | (c) | **8.** | (b) | **9.** | (c) | **10.** | (b) |
| **11.** | (b) | **12.** | (d) | **13.** | (a) | **14.** | (a) | **15.** | (c) |
| **16.** | (c) | **17.** | (d) | **18.** | (a) | **19.** | (a) | **20.** | (c,d) |
| **21.** | (a,b) | **22.** | (a,b,c) | **23.** | (a,d) | **24.** | (144) | **25.** | (3.42) |
| **26.** | (4) | **27.** | (b) | **28.** | (c) | **29.** | (b) | **30.** | (b) |

**16. (B) :**




**17. (C)**

**18. (A) :**




**19. (A) :** (I) $Cr^{2+}$ is a reducing agent, it gets oxidised to $Cr^{3+}$ ($3d^3$ or $t_{2g}^3$, stable half-filled configuration).

(II) $Mn^{3+}$ is an oxidizing agent, it gets reduced to $Mn^{2+}$ ($3d^5$, most stable, half-filled configuration).

(III) Cr (24) : $3d^4 4s^2$ ;

Mn (25) : $3d^5 4s^2$

$Cr^{2+}$ : $3d^4$

$Mn^{3+}$ : $3d^4$

Both $Cr^{2+}$ and $Mn^{3+}$ exhibit $d^4$ electronic configuration.

(IV) When $Cr^{2+}$ is used as a reducing agent, the chromium ion attains $d^3$ electronic configuration.

**20. (A) :** For a first order reaction, $\alpha$ is the degree of dissociation

$$\therefore \quad k \cdot t = \ln \frac{1}{1-\alpha} = -\ln (1-\alpha)$$

or $e^{-k.t.} = (1 - \alpha)$ or $\alpha = 1 - e^{-k.t}$

As, Arrhenius equation is, $k = A.e^{(-E_a/RT)}$

The dimensions of pre-exponential factor ($A$) are the same as those of $k$, which is $T^{-1}$ for a first order reaction.

*For other sections/subjects please refer to Physics For You and Biology Today*

# GET SET GO for NEET


*with exclusive and brain storming MCQs*

Practicing these MCQs help to strengthen your concepts and give you extra edge in your NEET preparation

**1.** Few general names are given along with their valence shell configurations. Mark the incorrect name.
(a) $ns^2\ np^6$ – Noble gases
(b) $ns^2\ np^5$ – Halogens
(c) $ns^1$ – Alkali metals
(d) $ns^2\ np^2$ – Chalcogens

**2.** The balancing of chemical equations is based upon the law of
(a) combining volumes
(b) multiple proportions
(c) conservation of mass
(d) definite proportions.

**3.** If the four tubes of a car are filled to the same pressure with $N_2$, $O_2$, $H_2$ and He separately, then which one will be filled first?
(a) $N_2$ (b) $O_2$ (c) $H_2$ (d) He

**4.** The nineteenth electron of chromium has which of the following set of quantum numbers?

| | *n* | *l* | *m* | *s* |
|---|---|---|---|---|
| (a) | 3 | 0 | 0 | + 1/2 |
| (b) | 3 | 2 | – 2 | + 1/2 |
| (c) | 4 | 0 | 0 | + 1/2 |
| (d) | 4 | 1 | – 1 | – 1/2 |

**5.** $sp^3d^2$ hybridization is observed in
(a) $BrF_3$ (b) $ClF_3$ (c) $BrCl_3$ (d) $ICl_5$

**6.** Which of the following does not result an increase in the entropy?
(a) Crystallisation of sucrose from solution
(b) Rusting of iron
(c) Conversion of ice to water
(d) Vaporisation of camphor

**7.** In a system $A_{(s)} \rightleftharpoons B_{(g)} + 2C_{(g)}$, doubling the equilibrium concentration of $B$ will cause the equilibrium concentration of $C$ to change to
(a) two times its original value
(b) one half of its original value
(c) $\frac{1}{\sqrt{2}}$ times the original value
(d) $\sqrt{2}$ times the original value.

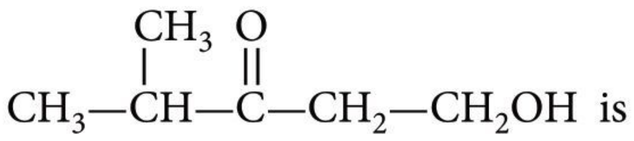
**8.** $KO_2$ (potassium superoxide) is used in oxygen cylinders in space and submarines because it
(a) absorbs $CO_2$ and increases $O_2$ content
(b) eliminates moisture
(c) absorbs $O_2$
(d) produces ozone.

**9.** Covalency of B in $BF_4^-$ is
(a) 5 (b) 4 (c) 3 (d) 2

**10.** Elements of group 14 exhibit oxidation state of
(a) +4 only (b) +2 and +4 only
(c) +1 and +3 only (d) +2 only.

**11.** Kjeldahl method for estimation of nitrogen is not applicable to
(a) pyridine
(b) hexamethylene diamine
(c) propan-1-amine
(d) 2-phenylethanamine.

**12.** The IUPAC name of



(a) 1-hydroxy-4-methylpentan-3-one
(b) 2-methyl-5-hydroxypentan-3-one
(c) 4-methyl-3-oxopentan-1-ol
(d) hexan-1-ol-3-one.

**13.** $CH \equiv CH \xrightarrow{O_3} X \xrightarrow{Zn/CH_3COOH} Y$

The compound *Y* is
(a) $CH_2OHCH_2OH$ (b) $CH_3COOH$
(c) $C_2H_5OH$ (d) $CH_3CH_3$

**14.** Acid rains are produced by
(a) excess $NO_2$ and $SO_2$ from burning fossil fuels
(b) excess production of $NH_3$ by industry and coal gas
(c) excess release of carbon monoxide by incomplete combustion
(d) excess formation of $CO_2$ by combustion and animal respiration.

**15.** Which of the following statements is correct if the intermolecular forces in liquids *A*, *B* and *C* are in the order $A < B < C$ ?
(a) *B* evaporates more readily than *A*.
(b) *B* evaporates less readily than *C*.
(c) *A* and *B* evaporate at the same rate.
(d) *A* evaporates more readily than *C*.

## SOLUTIONS

**1.** **(d) :** $ns^2np^2$ are members of carbon family. Chalcogens is the general name of group 16 elements.

**2.** **(c) :** Mass on both sides of the reaction equation should be conserved *i.e.*, no change is observed in the total mass of the substances involved in a chemical reaction.

**3.** **(c) :** We know that, $PM = dRT$

*i.e.*, at constant temperature, $P \propto \frac{1}{M}$

For the same pressure, the gas which has minimum molecular weight will be filled first. $H_2$ gas has minimum molecular weight among all, so $H_2$ will be filled first.

**4.** **(c) :** $_{24}Cr \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$
Nineteenth electron is $4s^1$.
For which $n = 4$, $l = 0$, $m = 0$, $s = \pm 1/2$

**5.** **(d) :** $ICl_5$ :

Total no. of hybridised orbitals $(H) = \frac{1}{2}(7+5) = 6$

$\Rightarrow sp^3d^2$

**6.** **(a) :** Crystallisation involves arrangement of molecules in a perfectly ordered manner *i.e.*, minimum randomness.

**7.** **(c) :** $K_{eq} = [B]\ [C]^2$
$K_{eq} = [B_1]\ [C_1]^2$ (Initially)
$K_{eq} = [2B_1]\ [C_2]^2$ (Finally)
As $K_{eq}$ is always constant,
$[B_1]\ [C_1]^2 = [2B_1]\ [C_2]^2$

$[C_2]^2 = \frac{[C_1]^2}{2}$ ; $[C_2] = \frac{1}{\sqrt{2}}[C_1]$

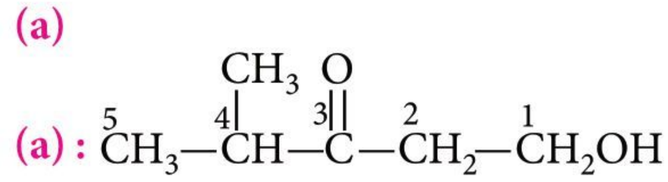
**8.** **(a) :** $4KO_2 + 2CO_2 \longrightarrow 2K_2CO_3 + 3O_2$

**9.** **(b) :** Covalency of B in $BF_4^-$ ion is 4, which is also its maximum covalency.

**10.** **(b) :** Outer electronic configuration of group-14 elements is $ns^2np^2$.
Thus, they can exhibit +2 oxidation state by losing 2 *p*-electrons or +4 oxidation state by losing all 4 valence electrons.

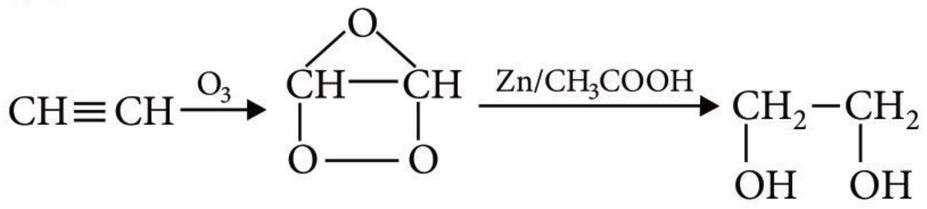
**11.** **(a)**

**12.** **(a) :**



1-Hydroxy-4-methylpentan-3-one

**13.** **(a) :**



**14.** **(a) :** Acid rains are produced by excess $NO_2$ and $SO_2$ from burning fossil fuels.

**15.** **(d) :** Weaker the intermolecular forces, more readily the evaporation will take place.

BRUSH UP

for

# NEET/JEE

CLASS-XI

**Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.**

## Unit 4 Equilibrium

- **Equilibrium** can be established for both physical processes and chemical reactions.
- At equilibrium, two opposing processes (forward and reverse) take place at equal rates and hence, it is called **dynamic equilibrium**.

## Physical Equilibrium

- Involves physical changes only; includes phase transformation: Solid ⇌ Liquid; Liquid ⇌ Gas; Solid ⇌ Gas.
- Solid ⇌ Saturated solution of solid in liquid.
- Gas ⇌ Saturated solution of gas in liquid.
- Freezing point/melting point : Temperature at which Solid ⇌ Liquid, under 1 atm pressure.
- Boiling point : Temperature at which Liquid ⇌ Gas, at 1 atm pressure.

### Reversible Reactions

- A reaction which takes place not only in the forward direction but also in the backward direction under the same conditions is called a reversible reaction.
- Ultimately a stage comes in a reversible reaction, where concentration of both reactant and product becomes equal, which is said to be equilibrium.

### Irreversible Reactions

- These are the reactions in which products do not react back to give reactants.

## Law of Chemical Equilibrium

- Law of chemical equilibrium is a result obtained by applying the law of mass action to a reversible reaction in equilibrium.
- For example, consider a general reversible reaction,

$aA + bB \rightleftharpoons cC + dD$

$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ ; where, $K_c$ is equilibrium constant.

$K_c$ is specific for a reaction and this equation is known as law of chemical equilibrium.

**Equilibrium constant of a chemical reaction**

| When the equation is | Equilibrium constant |
|---|---|
| reversed | $1/K$ |
| divided by 2 | $\sqrt{K}$ |
| multiplied by 2 | $K^2$ |
| divided into 2 steps | $K = K_1 \times K_2$ |

- For a gas phase reaction, $aA + bB \rightleftharpoons cC + dD$

$K_p = \frac{(p_C)^c(p_D)^d}{(p_A)^a(p_B)^b}$ and $K_p = K_c(RT)^{\Delta n_g}$;

where, $\Delta n = (n_{\text{gaseous products}} - n_{\text{gaseous reactants}})$

- If $\Delta n_g = 0$, $K_p = K_c$
- If $\Delta n_g$ = +ve (*i.e.*, $n_p > n_r$), $K_p > K_c$
- If $\Delta n_g$ = –ve (*i.e.*, $n_p < n_r$), $K_p < K_c$

### Types of Chemical Equilibrium

- **Homogeneous equilibrium :** All the reactants and products are in the same phase.

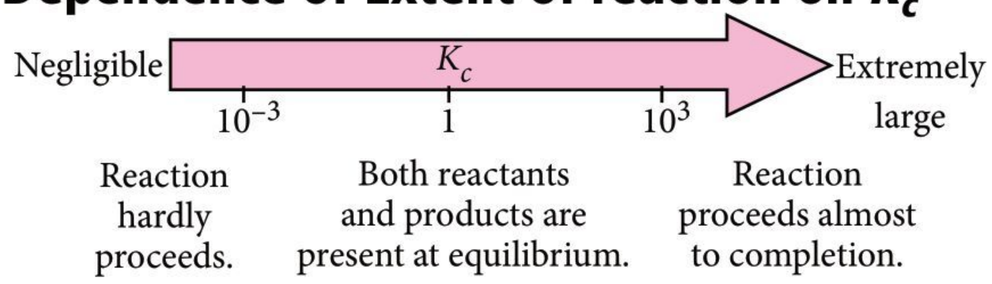
$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

- **Heterogeneous equilibrium :** Reactants and products are in two or more different phases.

$$C_{(s)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + H_{2(g)}$$

## Applications of Equilibrium Constant

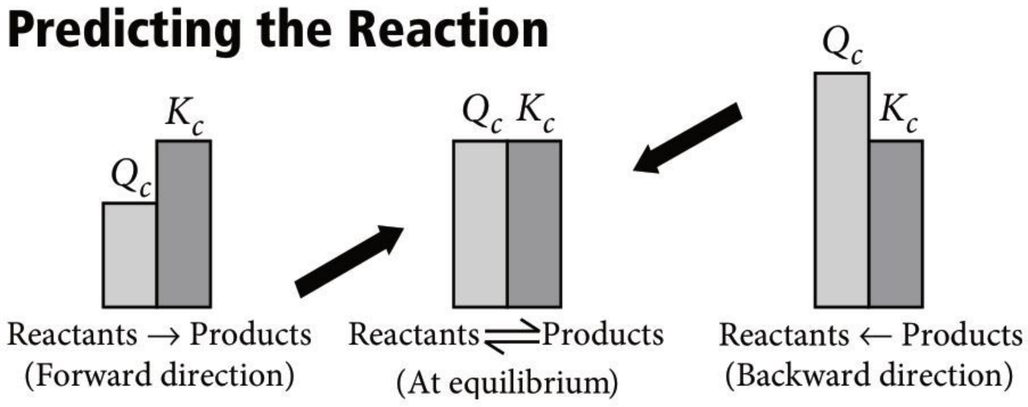
### Dependence of Extent of reaction on $K_c$




- If the reaction is not at equilibrium then reaction quotient '$Q_c$' is used instead of equilibrium constant '$K_c$'.

$$\text{Thus, } Q_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

### Predicting the Reaction




### Relation between Gibbs Free Energy and Equilibrium Constant

At equilibrium, $\Delta G^\circ = -RT \ln K$; $K = e^{-\Delta G^\circ/RT}$

- If $\Delta G^\circ < 0$, then $K > 1$ [Forward reaction is favoured.]
- If $\Delta G^\circ > 0$, then $K < 1$ [Reverse reaction is favoured.]
- If $\Delta G^\circ = 0$, then $K = 1$ [Reaction is at equilibrium.]

## Le Chatelier's Principle

- If a system in equilibrium is subjected to a change of concentration, temperature or pressure, the equilibrium shifts in a direction so as to undo the effect of the change imposed.

### Effect of Temperature on Equilibrium Constant

$$\frac{d \ln K_p}{dT} = \frac{\Delta H^\circ}{RT^2}; \log \frac{K_2}{K_1} = \frac{\Delta H^\circ}{2.303R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$$

- If $\Delta H = 0$, *i.e.*, no heat is evolved or absorbed in the reaction, $\log (K_2/K_1) = 0$, or $K_2/K_1 = 1$ or $K_2 = K_1$ *i.e.*, equilibrium constant does not change with temperature.
- If $\Delta H$ = +ve, *i.e.*, heat is absorbed in the reaction, then $\log (K_2/K_1)$ = +ve or $\log K_2 > \log K_1$ or $K_2 > K_1$ *i.e.*, equilibrium constant increases with increase in temperature.
- If $\Delta H$ = –ve, *i.e.*, heat is evolved in the reaction, $\log (K_2/K_1)$ = –ve or $\log K_2 < \log K_1$ or $K_2 < K_1$ *i.e.*, equilibrium constant decreases with increase in temperature.

## Ionic Equilibrium

- Substances that conduct electricity in their aqueous solutions or in molten state are called **electrolytes.**
- **Strong electrolytes** are completely ionised in aqueous solutions and **weak electrolytes** are partially ionised in aqueous solutions.
- In weak electrolytes, an equilibrium is established between ions and unionised molecules, leading to an ionic equilibrium in the aqueous solution. All acids, bases and salts may be classified as weak or strong electrolytes.
- Degree of dissociation ($\alpha$) = $\dfrac{\text{No. of moles dissociated}}{\text{Total no. of moles taken}}$

For strong electrolytes, $\alpha = 1$ and for weak electrolytes, $\alpha < 1$.

- **Ostwald's dilution law :** For a binary electrolyte *AB*.

| | $AB \rightleftharpoons$ | $A^+ +$ | $B^-$ |
|---|---|---|---|
| Initial concentration | $C$ | 0 | 0 |
| Conc. at equilibrium | $C(1-\alpha)$ | $C\alpha$ | $C\alpha$ |

where, $\alpha$ is degree of dissociation.

$$K_a = \frac{[A^+][B^-]}{[AB]} = \frac{C\alpha \times C\alpha}{C(1-\alpha)} = \frac{C\alpha^2}{1-\alpha}$$

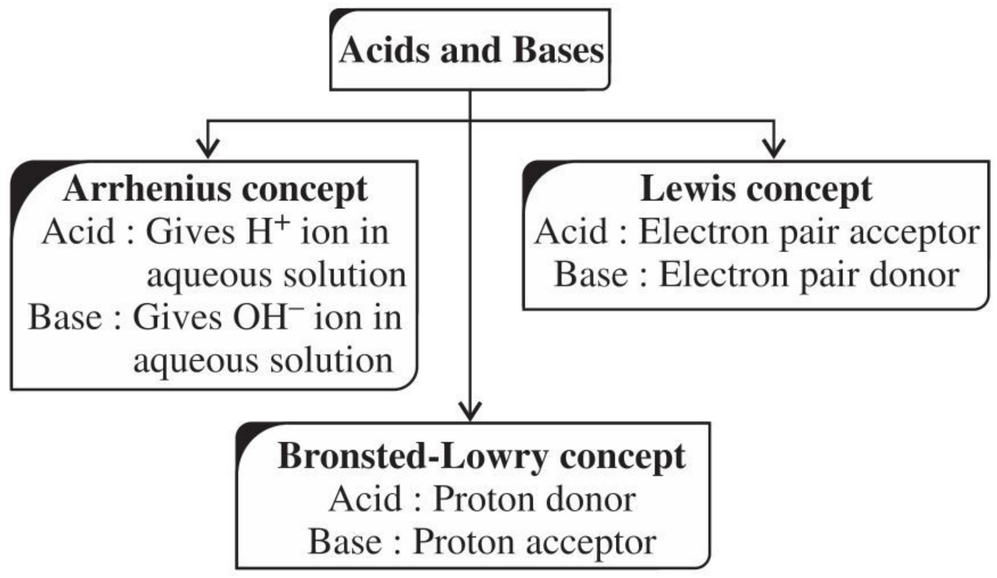
where, $K_a$ is called dissociation or ionisation constant.

For a weak electrolyte, $\alpha <<< 1$ and $1 - \alpha \approx 1$

$$K_a = C\alpha^2 \text{ or } \alpha = \sqrt{\frac{K_a}{C}} \text{ or } \alpha = \sqrt{K_a V}$$

where, $V$ is the volume containing one mole of electrolyte.

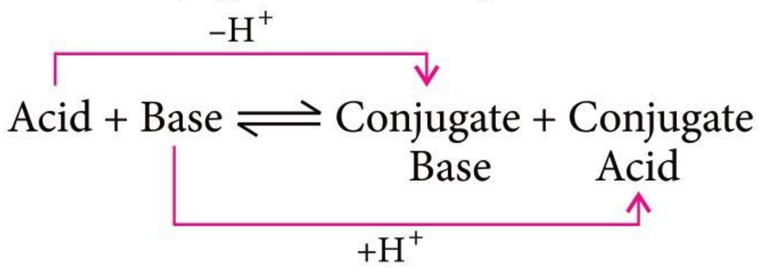
## Acids and Bases




| | |
|---|---|
| Strong acids : *e.g.*, HCl, $H_2SO_4$, $HNO_3$ | Weak acids : *e.g.*, $CH_3COOH$, $H_2CO_3$ |
| Strong bases : *e.g.*, NaOH, KOH, CsOH | Weak bases : *e.g.*, $NH_4OH$, $Cu(OH)_2$ |

## Conjugate Acid-Base Pair

- A pair of acid and base, which differs by a proton is known as conjugate acid-base pair.




## Ionisation of Acids and Bases

$HA \rightleftharpoons H^+ + A^-$;
(Acid)

$$K_a = \frac{[H^+][A^-]}{[HA]} \text{ and } \alpha = \sqrt{\frac{K_a}{C}}$$

$BOH \rightleftharpoons B^+ + OH^-$;
(Base)

$$K_b = \frac{[B^+][OH^-]}{[BOH]} \text{ and } \alpha = \sqrt{\frac{K_b}{C}}$$

- Greater the degree of ionisation ($\alpha$), greater is the dissociation constant ($K_a$ or $K_b$) and stronger is the acid or base.
- **Polybasic acids and polyacidic bases :** Polybasic acids and polyacidic bases ionise stepwise and each step has its own ionisation constant such as $K_1$, $K_2$, $K_3$... . Higher order ionisation constants ($K_2$, $K_3$...) are smaller than the lower ionisation constant ($K_1$) of a polyprotic acid.
  $K = K_1 \times K_2 \times K_3$ ... and generally $K_1 > K_2 > K_3 > .....$
- **Factors affecting acid strength :** Strength of an acid (H*A*) depends on the strength and polarity of the H—*A* bond.

Size increases →
HF << HCl << HBr << HI
→ Acid strength increases

Electronegativity increases →
$CH_4 < NH_3 < H_2O < HF$
→ Acid strength increases

- The addition of a substance that suppresses the dissociation of weak electrolyte due to the presence of common ion is called common ion effect.

## Salt Hydrolysis

| Salt | Hydrolysis | Resulting solution | Hydrolysis constant ($K_h$) | Degree of hydrolysis ($h$) | pH |
|---|---|---|---|---|---|
| Weak acid and Strong base | Anionic | Alkaline, pH > 7 | $K_h = \frac{K_w}{K_a}$ | $h = \sqrt{\frac{K_h}{C}}$ | $pH = \frac{1}{2}[pK_w + pK_a + \log C]$ |
| Strong acid and Weak base | Cationic | Acidic, pH < 7 | $K_h = \frac{K_w}{K_b}$ | $h = \sqrt{\frac{K_h}{C}}$ | $pH = \frac{1}{2}[pK_w - pK_b - \log C]$ |
| Weak acid and Weak base | Anionic and cationic both | Neutral, pH = 7 (If $K_a = K_b$) | $K_h = \frac{K_w}{K_a K_b}$ | $h = \sqrt{K_h}$ | $pH = \frac{1}{2}[pK_w + pK_a - pK_b]$ |

## Calculation of pH and pOH in Different Types of Solutions

| | Types of solution | Formula |
|---|---|---|
| 1. | Dilute aqueous solution of a strong acid or a strong base | $pH = -\log\{[H^+]_{acid} + [H^+]_{H_2O}\}$<br>$pOH = -\log\{[OH^-]_{base} + [OH^-]_{H_2O}\}$ |
| 2. | Highly concentrated solution of a strong acid or a strong base (concentration > 1 M) | pH of acidic solution is taken as 0.<br>pH of basic solution is taken as 14. |
| 3. | Solution of a weak acid or a weak base | $pH = -\log(C\alpha) = -\log\sqrt{K_a C}$<br>$pOH = -\log(C\alpha) = -\log\sqrt{K_b C}$ |
| 4. | Mixture of two or more strong monoprotic acids or strong bases | $pH = -\log\left(\frac{\Sigma NV}{\Sigma V}\right)$, $pOH = -\log\left(\frac{\Sigma NV}{\Sigma V}\right)$ |

| | | |
|---|---|---|
| 5. | Mixture of an acid and a base | $\text{pH} = -\log\left(\frac{(N_1V_1)_{\text{acid}} - (N_2V_2)_{\text{base}}}{V_1 + V_2}\right)$ (If acid is in excess.) $\text{pOH} = -\log\left(\frac{(N_2V_2)_{\text{base}} - (N_1V_1)_{\text{acid}}}{V_1 + V_2}\right)$ (If base is in excess.) |
| 6. | Amphiprotic system | $\text{pH} = \frac{\text{p}K_{a_1} + \text{p}K_{a_2}}{2}$ |

## Solubility Product

- A solid salt of the general formula, $A_xB_y$ with molar solubility '$S$' in equilibrium with its saturated solution may be represented by the equation :

$A_xB_y \rightleftharpoons xA^{y+} + yB^{x-}$

$K = \frac{[A^{y+}]^x[B^{x-}]^y}{[A_xB_y]}$ ; $K[A_xB_y] = [A^{y+}]^x\,[B^{x-}]^y$

$\because$ $[A_x\,B_y]$ in solid state remains constant,

$\therefore$ $[A^{y+}]^x\,[B^{x-}]^y = K_{sp}$.

- $K_{sp}$ is given by $Q_{sp}$, when the concentration of one or more species is not the concentration under equilibrium, and under equilibrium conditions $K_{sp} = Q_{sp}$.

| Salt type | Relation between $K_{sp}$ and $S$ | Examples |
|---|---|---|
| $AB_2$ | $K_{sp} = (S)(2S)^2 = 4S^3$ | $PbCl_2$, $HgCl_2$ |
| $A_2B$ | $K_{sp} = (2S)^2(S) = 4S^3$ | $Ag_2CrO_4$, $Ag_2C_2O_4$, $Ag_2SO_4$ |
| $AB_3$ | $K_{sp} = (S)(3S)^3 = 27S^4$ | $Fe(OH)_3$, $Al(OH)_3$, $Cr(OH)_3$ |
| $A_3B_2$ | $K_{sp} = (3S)^3(2S)^2 = 108S^5$ | $Ca_3(PO_4)_2$, $Zn_3(PO_4)_2$ |
| $AB$ | $K_{sp} = (S)(S) = S^2$ | AgCl, AgBr, $PbSO_4$, $BaSO_4$, ZnS |

**Buffer Solutions**

**Acidic buffer**
Contains an equimolar mixture of a weak acid and its salt with a strong base.
*e.g.*, $CH_3COOH$ and $CH_3COONa$

**Basic buffer**
Contains an equimolar mixture of a weak base and its salt with a strong acid.
*e.g.*, $NH_4OH$ and $NH_4Cl$

- **pH of an acidic buffer :**

$\text{pH} = \text{p}K_a + \log\frac{[\text{Salt}]}{[\text{Acid}]} = \text{p}K_a + \log\frac{[\text{Conjugate base}]}{[\text{Acid}]}$

**(Henderson—Hasselbalch equation)**

- **pH of a basic buffer :**

$\text{pOH} = \text{p}K_b + \log\frac{[\text{Salt}]}{[\text{Base}]}$

$= \text{p}K_b + \log\frac{[\text{Conjugate acid}]}{[\text{Base}]}$

$\text{pH} = 14 - \text{pOH}$

## ANSWERS NOVEMBER 2022 : WORD GRID

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | C | E | T | I | C | A | N | H | Y | D | R | I | D | E | T |
| C | Y | N | M | K | Y | C | W | G | O | I | E | A | O | P | R |
| Y | A | D | N | A | W | D | X | F | L | L | D | N | A | Q | A |
| W | N | A | P | L | X | F | Y | E | K | U | Y | M | B | S | N |
| S | I | C | Q | A | X | G | Z | D | A | T | X | D | C | W | Q |
| T | D | D | O | C | M | H | B | C | R | I | W | L | E | Z | U |
| U | E | E | R | T | N | J | L | M | M | O | Y | K | F | R | I |
| D | R | Z | S | O | O | K | O | N | A | N | Z | G | H | M | L |
| E | W | Y | T | S | M | P | Q | R | S | T | U | J | I | N | I |
| N | X | E | L | E | C | T | R | O | P | H | I | L | E | R | Z |
| T | B | N | F | X | U | U | C | C | D | B | A | X | W | T | E |
| Y | C | L | T | Y | R | U | I | N | D | I | C | A | T | O | R |
| W | D | A | U | Z | I | V | W | Y | B | N | M | L | J | H | F |
| X | E | R | W | T | E | X | Z | A | O | C | D | E | K | I | G |

1. Curie
2. Cyanide
3. Electrophile
4. Dilution
5. Indicator
6. Lactose
7. Tranquilizer
8. Acetic Anhydride

*Winner : Ananya Goswami*

# WRAP it up!

## MCQs TYPE QUESTIONS

**1.** If $K_{sp(AgCNS)} = 1 \times 10^{-12}$ and $K_{sp(AgBr)} = 5 \times 10^{-13}$, then the values of simultaneous solubility of AgCNS and AgBr in a solution of water will be

(a) $8.16 \times 10^{-7}, 4.08 \times 10^{-7}$

(b) $4.08 \times 10^{-7}, 8.16 \times 10^{-7}$

(c) 8.16, 4.08

(d) $1 \times 10^{-12}, 5 \times 10^{-13}$

**2.** 0.20 mole of $NH_4Cl$ are introduced into an empty container of 10 litre and heated to 327 °C to attain equilibrium as :

$NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$ ; $K_p = 0.36\ atm^2$.

The quantity of solid $NH_4Cl$ left is

(a) 0.02 mole (b) 0.078 mole

(c) 0.095 mole (d) 0.035 mole.

**3.** If $K_1$ and $K_2$ are the respective equilibrium constants for the two reactions,

$XeF_{6(g)} + H_2O_{(g)} \rightleftharpoons XeOF_{4(g)} + 2HF_{(g)}$

$XeO_{4(g)} + XeF_{6(g)} \rightleftharpoons XeOF_{4(g)} + XeO_3F_{2(g)}$

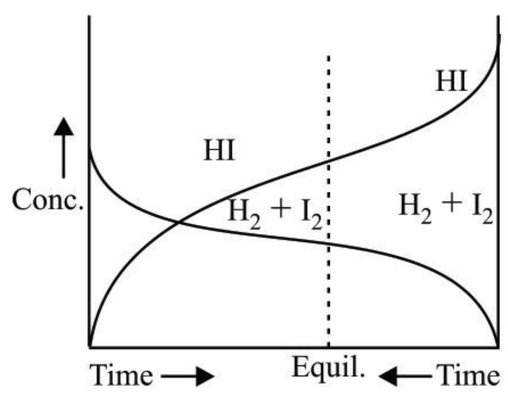
The equilibrium constant for the reaction,

$XeO_{4(g)} + 2HF_{(g)} \rightleftharpoons XeO_3F_{2(g)} + H_2O_{(g)}$ is

(a) $K_1K_2$ (b) $K_1/K_2^2$

(c) $K_2 / K_1$ (d) $K_1 / K_2$

**4.** Consider the following graph and mark the correct statement.




(a) Chemical equilibrium in the reaction, $H_2 + I_2 \rightleftharpoons 2HI$ can be attained from either directions.

(b) Equilibrium can be obtained when $H_2$ and $I_2$ are mixed in an open vessel.

(c) The concentrations of $H_2$ and $I_2$ keep decreasing while concentration of HI keeps increasing with time.

(d) We can find out equilibrium concentration of $H_2$ and $I_2$ from the given graph.

**5.** Match the column I with column II and mark the appropriate choice.

| Column I | | Column II | |
|---|---|---|---|
| (A) | Liquid $\rightleftharpoons$ Vapour | (i) | Saturated solution |
| (B) | Solid $\rightleftharpoons$ Liquid | (ii) | Boiling point |
| (C) | Solid $\rightleftharpoons$ Vapour | (iii) | Sublimation point |
| (D) | Solute(*s*) $\rightleftharpoons$ Solute(solution) | (iv) | Melting point |

(a) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)

(b) (A) → (ii), (B) → (iv), (C) → (iii), (D) → (i)

(c) (A) → (iv), (B) → (ii), (C) → (i), (D) → (iii)

(d) (A) → (iii), (B) → (iv), (C) → (ii), (D) → (i)

**6.** For a reaction, $2NOCl_{(g)} \rightleftharpoons 2NO_{(g)} + Cl_{2(g)}$, $K_c$ at 427 °C is $3 \times 10^{-6}$ L $mol^{-1}$. The value of $K_p$ is nearly

(a) $7.5 \times 10^{-5}$ (b) $2.5 \times 10^{-5}$

(c) $2.5 \times 10^{-4}$ (d) $1.72 \times 10^{-4}$

**7.** A solution is 0.1 M with respect to $Ag^+$, $Ca^{2+}$, $Mg^{2+}$ and $Al^{3+}$. Which will precipitate at lowest concentration of $PO_4^{3-}$ ion when $Na_3PO_4$ solution is added?

(a) $Ag_3PO_4 (K_{sp} = 1 \times 10^{-6})$

(b) $Ca_3(PO_4)_2\ (K_{sp} = 1 \times 10^{-33})$

(c) $Mg_3(PO_4)_2 (K_{sp} = 1 \times 10^{-24})$

(d) $AlPO_4 (K_{sp} = 1 \times 10^{-20})$

**8.** $\frac{K_p}{K_c}$ for following reaction will be

$CO_{(g)} + \frac{1}{2} O_{2(g)} \rightarrow CO_{2(g)}$

(a) $RT$ (b) $\frac{1}{RT}$ (c) $\frac{1}{\sqrt{RT}}$ (d) $\frac{RT}{2}$

**9.** The value of $K_c$ for the following equilibrium is

$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$.

Given $K_p = 167$ bar at 1073 K.

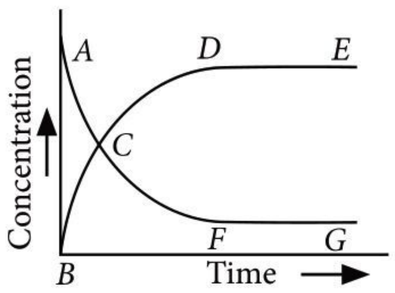
(a) 1.896 mol $L^{-1}$ (b) $4.38 \times 10^{-4}$ mol $L^{-1}$

(c) $6.3 \times 10^4$ mol $L^{-1}$ (d) 6.626 mol $L^{-1}$

**10.** Reversible reaction is studied graphically as shown in the given figure.

$N_2O_4 \rightleftharpoons 2NO_2$, $K_c = 4$

Select the correct statements out of I, II and III.



I. Reaction quotient has maximum value at point *A*.
II. Reaction proceeds left to right at a point when $[N_2O_4] = [NO_2] = 0.1$ M.
III. $K_c = Q$ when point *D* or *F* is reached.
(a) I, II (b) II, III (c) I, III (d) I, II, III

**11.** Which of the following will produce a buffer solution when mixed in equal volumes?
(a) 0.1 mol $dm^{-3}$ $NH_4OH$ and 0.1 mol $dm^{-3}$ HCl
(b) 0.05 mol $dm^{-3}$ $NH_4OH$ and 0.1 mol $dm^{-3}$ HCl
(c) 0.1 mol $dm^{-3}$ $NH_4OH$ and 0.05 mol $dm^{-3}$ HCl
(d) 0.1 mol $dm^{-3}$ $CH_3COONa$ and 0.1 mol $dm^{-3}$ NaOH

**12.** A buffer solution contains 0.1 mole of sodium acetate dissolved in 1000 $cm^3$ of 0.1 M acetic acid. To the above buffer solution, 0.1 mole of sodium acetate is further added and dissolved. The pH of the resulting buffer is
(a) $pK_a$ (b) $pK_a + 2$
(c) $pK_a - \log 2$ (d) $pK_a + \log 2$

**13.** **Assertion :** The reaction,
$2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$ is favoured in the forward direction with increase of pressure.
**Reason :** The reaction is exothermic.
(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Both assertion and reason are false.

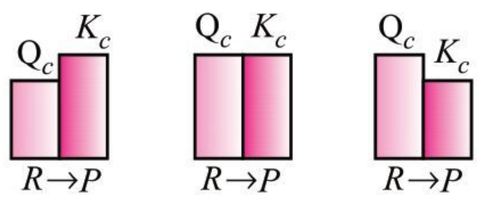
**14.** If $K_{sp}$ of *M*OH is $1 \times 10^{-10}$, then pH of its aqueous solution will be
(a) 3 (b) 6 (c) 9 (d) 12

**15.** Solid $Ba(NO_3)_2$ is gradually dissolved in a $1.0 \times 10^{-4}$ M $Na_2CO_3$ solution. At what concentration of $Ba^{2+}$ will a precipitate begin to form?
($K_{sp}$ for $BaCO_3 = 5.1 \times 10^{-9}$)
(a) $4.1 \times 10^{-5}$ M (b) $5.1 \times 10^{-5}$ M
(c) $8.1 \times 10^{-8}$ M (d) $8.1 \times 10^{-7}$ M

**16.** **Statement-I :** The equilibrium constant is fixed and it is a characteristic for any given chemical reaction at a specified temperature.
**Statement-II :** The composition of the final equilibrium mixture at a particular temperature depends upon the starting amount of reactants.
(a) Both statement-I and statement-II are true and statement-II is the correct explanation of statement-I.
(b) Both statement-I and statement-II are true but statement-II is not the correct explanation of statement-I.
(c) Statement-I is true but statement-II is false.
(d) Both statement-I and statement-II are false.

**17.** At 500 K, the equilibrium constant for the reaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ is 24.8. If $\frac{1}{2}$ mol/L of HI is present at equilibrium, what are the concentrations of $H_2$ and $I_2$, assuming that we started by taking HI and reached the equilibrium at 500 K?
(a) 0.068 mol $L^{-1}$ (b) 1.020 mol $L^{-1}$
(c) 0.10 mol $L^{-1}$ (d) 1.20 mol $L^{-1}$

**18.** Predict the direction of the reaction from the comparison of $Q_c$ and $K_c$. Mark the incorrect statement.




(a) If $Q_c < K_c$, reaction goes from left to right.
(b) If $Q_c = K_c$, reaction goes from right to left.
(c) If $Q_c > K_c$, net reaction goes from right to left.
(d) If $Q_c = K_c$, reactants and products are at equilibrium.

**19.** Match the column I with column II and mark the appropriate choice.

| Column I | | Column II | |
|---|---|---|---|
| (A) | $Fe(OH)_3$ | (i) | $K_{sp} = s^2$ |
| (B) | $Ag_2CrO_4$ | (ii) | $K_{sp} = 27s^4$ |
| (C) | $CH_3COOAg$ | (iii) | $K_{sp} = 108s^5$ |
| (D) | $Ca_3(PO_4)_2$ | (iv) | $K_{sp} = 4s^3$ |

(a) (A) → (iii), (B) → (ii), (C) → (iv), (D) → (i)
(b) (A) → (ii), (B) → (iv), (C) → (i), (D) → (iii)
(c) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)
(d) (A) → (iv), (B) → (i), (C) → (iii), (D) → (ii)

**20.** Given below are the dissociation constant values of few acids. Arrange them in order of increasing acidic strength.
$H_2SO_3 = 1.3 \times 10^{-2}$, $HNO_2 = 4 \times 10^{-4}$,
$CH_3COOH = 1.8 \times 10^{-5}$, $HCN = 4 \times 10^{-10}$
(a) $HCN < CH_3COOH < HNO_2 < H_2SO_3$
(b) $CH_3COOH < HNO_2 < HCN < H_2SO_3$
(c) $CH_3COOH < HCN < H_2SO_3 < HNO_2$
(d) $HNO_2 < H_2SO_3 < CH_3COOH < HCN$

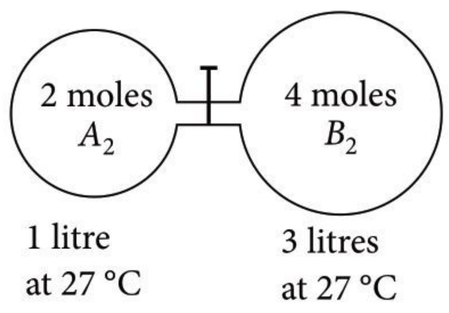
## NUMERICAL VALUE TYPE QUESTIONS

**21.** The $pK_a$ of a weak acid (*HA*) is 4.5. The pOH of an aqueous buffered solution of *HA* in which 50% of the acid is ionised is _____.

**22.** The minimum concentration of $SO_4^{2-}$ required to precipitate $BaSO_4$ in a solution containing $1 \times 10^{-4}$ mole of $Ba^{2+}$ is_____ $\times 10^{-6}$ M.
($K_{sp}$ for $BaSO_4 = 4 \times 10^{-10}$)

**23.** pH of a saturated solution of magnesium hydroxide in water at 298 K is 10. The solubility of the hydroxide in water at 298 K is ____$\times 10^{-5}$ moL $L^{-1}$.

**24.** The gas $A_2$ in the left flask allowed to react with gas $B_2$ present in right flask as $A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$; $K_c = 4$ at 27 °C. The concentration of $AB$ when equilibrium is established is _____M.




**25.** The minimum pH required to prevent the precipitation of ZnS in a solution that is 0.01 M $ZnCl_2$ and saturated with 0.10 M $H_2S$ is _____.
(Given : $K_{sp} = 10^{-21}$, $K_{a_1} \times K_{a_2} = 10^{-20}$)

## SOLUTIONS

**1. (a)**

**2. (b):**

| | $NH_4Cl_{(s)} \rightleftharpoons$ | $NH_{3(g)}$ + | $HCl_{(g)}$ |
|---|---|---|---|
| moles at $t = 0$ | 0.20 | 0 | 0 |
| moles at eq. | (0.20 – $a$) | $a$ | $a$ |

Also, $K_p = p_{NH_3} \times p_{HCl} = p^2$

$p = \sqrt{K_p} = \sqrt{0.36} = 0.6$ atm

$p = 0.6$ atm, $V = 10$ L, $R = 0.0821$ L atm $mol^{-1}K^{-1}$, $T = 600$ K

$pV = nRT \Rightarrow 0.6 \times 10 = n \times 0.0821 \times 600$

$n = 0.1218$; $n$ of $NH_4Cl$ left $= 0.2 - 0.1218 = 0.078$ mole

**3. (c):** $K_1 = \dfrac{[XeOF_4][HF]^2}{[XeF_6][H_2O]}$ ...(i)

$K_2 = \dfrac{[XeOF_4][XeO_3F_2]}{[XeO_4][XeF_6]}$ ...(ii)

Dividing Eq. (ii) by (i) we have,

$\dfrac{K_2}{K_1} = \dfrac{[XeO_3F_2][H_2O]}{[XeO_4][HF]^2} = K'$

**4. (a):** Equilibrium can be attained by either side of the reactions of equilibrium.

**5. (b):** (A) Liquid $\rightleftharpoons$ Vapour; equilibrium exists at the boiling point.
(B) Solid $\rightleftharpoons$ Liquid; equilibrium exists at the melting point.
(C) Solid $\rightleftharpoons$ Vapour; equilibrium exists at the sublimation point.
(D) $Solute_{(s)} \rightleftharpoons$ Solute(solution) equilibrium exists in a saturated solution.

**6. (d):** $2NOCl_{(g)} \rightleftharpoons 2NO_{(g)} + Cl_{2(g)}$

$\Delta n_{(g)} = 3 - 2 = 1$

$K_p = K_c(RT)^{\Delta n_{(g)}} = (3 \times 10^{-6}) \times (0.0821 \times 700)$
$= 172.41 \times 10^{-6} = 1.72 \times 10^{-4}$

**7. (d):** (a) $Ag_3PO_4 \underset{(0.1)}{\rightleftharpoons} 3Ag^+ + PO_4^{3-}$

$K_{sp} = [Ag^+]^3[PO_4^{3-}]$

$[PO_4^{3-}] = \dfrac{K_{sp}}{(0.1)^3} = \dfrac{1 \times 10^{-6}}{10^{-3}} = 10^{-3}$ M

(b) $Ca_3(PO_4)_2 \underset{(0.1)}{\rightleftharpoons} 3Ca^{2+} + 2PO_4^{3-}$

$K_{sp} = [Ca^{2+}]^3 [PO_4^{3-}]^2$

$10^{-33} = (0.1)^3 [PO_4^{3-}]^2$

$[PO_4^{3-}]^2 = \dfrac{10^{-33}}{10^{-3}} = 10^{-30}$

$[PO_4^{3-}] = 10^{-15}$ M

(c) $Mg_3(PO_4)_2 \underset{(0.1)}{\rightleftharpoons} 3Mg^{2+} + 2PO_4^{3-}$

$[PO_4^{3-}]^2 = \dfrac{10^{-24}}{10^{-3}} = 10^{-21}$

$[PO_4^{3-}] = 3.16 \times 10^{-11}$ M

(d) $AlPO_4 \underset{(0.1)}{\rightleftharpoons} Al^{3+} + PO_4^{3-}$

$\left[PO_4^{3-}\right] = \dfrac{K_{sp}}{0.1} = \dfrac{10^{-20}}{0.1} = 10^{-19}$ M

Lower the value of $K_{sp}$, lower will be solubility and will precipitate out first.

**8. (c):** $\Delta n_g = n_p - n_r = 1 - \dfrac{3}{2} = \dfrac{-1}{2}$

Hence, $K_p = K_c(RT)^{-1/2}$; $\dfrac{K_p}{K_c} = \dfrac{1}{(RT)^{1/2}} = \dfrac{1}{\sqrt{RT}}$

**9. (a):** $K_p = K_c(RT)^{\Delta n}$; $K_p = 167$ bar, $\Delta n = 1$

$K_c = \dfrac{167 \text{ bar}}{0.0821 \text{ L bar } K^{-1}mol^{-1} \times 1073 \text{ K}} = 1.896 \text{ mol } L^{-1}$

**10. (b):** (I) $Q = \dfrac{[NO_2]^2}{[N_2O_4]}$

Since, $[NO_2]$ is minimum and $[N_2O_4]$ is maximum at point *A*, hence *Q* is minimum at this point. Thus, false.

(II) $Q = \dfrac{(0.1)^2}{(0.1)} = 0.1 < K_c$

Thus, reaction proceeds left to right. Thus, true.

(III) $K_c = Q$ when equilibrium is reached at point *D* or *F*. Thus, true.

**11. (c) :** In option (c), all HCl will be neutralised and $NH_4Cl$ will be formed. Also, some $NH_4OH$ will be left unneutralised. Thus, the final solution will contain $NH_4OH$ and $NH_4Cl$ and it will form a buffer.

**12. (d):** Number of moles of acetic acid = 0.1 mol

Total number of moles of sodium acetate present in buffer solution = 0.1 + 0.1 = 0.2 mol

$$\therefore \quad pH = pK_a + \log \frac{[CH_3COONa]}{[CH_3COOH]}$$

$$= pK_a + \log \frac{0.2}{0.1} = pK_a + \log 2$$

$$\therefore \quad pH = pK_a + \log 2$$

**13. (b):** According to Le Chatelier's principle, with increase of pressure, equilibrium shifts in that direction in which lesser number of moles of gaseous products are produced.

**14. (c) :** $K_{sp}$ of $MOH = 1 \times 10^{-10}$

$[M^+]\,[OH^-] = 1 \times 10^{-10}$

Now, $[M^+] = [OH^-]$

$\therefore \quad [OH^-]^2 = 1 \times 10^{-10}$ or $[OH^-] = 10^{-5}$

$$[H_3O^+] = \frac{10^{-14}}{10^{-5}} = 10^{-9};\ pH = -\log(10^{-9}) = 9$$

**15. (b):** $K_{sp}\,(BaCO_3) = [Ba^{2+}][CO_3^{2-}] = 5.1 \times 10^{-9}$

Given, $[CO_3^{2-}] = 1.0 \times 10^{-4}$ M (from $Na_2CO_3$)

$\therefore \ 5.1 \times 10^{-9} = [Ba^{2+}] \times (10^{-4})$

$\Rightarrow [Ba^{2+}] = 5.1 \times 10^{-5}$ M

Thus, when $[Ba^{2+}] = 5.1 \times 10^{-5}$ M, $BaCO_3$ precipitate will begin to form.

**16. (c) :** The equilibrium constant is always fixed and it is a characteristic of a reaction at specified temperature. It defines the composition of the final equilibrium mixture of that reaction, regardless of the starting amount of reactants and products.

**17. (c) :**

$$2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)};\quad K_c = 1/24.8$$

| | | | |
|---|---|---|---|
| Initial conc. | 1 | 0 | 0 |
| At equilibrium | 0.5 | $x$ | $x$ |

$$K_c = \frac{[H_2][I_2]}{[HI]^2} \text{ or } \frac{1}{24.8} = \frac{x.x}{0.5 \times 0.5} \text{ or } x^2 = \frac{0.25}{24.8} = 0.010$$

$x = 0.10$ mol $L^{-1}$

**18. (b):** If $Q_c = K_c$, reaction is in equilibrium.

**19. (b):** (A) $Fe(OH)_3 \rightleftharpoons \underset{s}{Fe^{3+}} + \underset{(3s)^3}{3OH^-}$ ; $K_{sp} = 27s^4$

(B) $Ag_2CrO_4 \rightleftharpoons \underset{(2s)^2}{2Ag^+} + \underset{s}{CrO_4^{2-}}$ ; $K_{sp} = 4s^3$

(C) $CH_3COOAg \rightleftharpoons \underset{s}{CH_3COO^-} + \underset{s}{Ag^+}$ ; $K_{sp} = s^2$

(D) $Ca_3(PO_4)_2 \rightleftharpoons \underset{(3s)^3}{3Ca^{2+}} + \underset{(2s)^2}{2PO_4^{3-}}$ ; $K_{sp} = 108s^5$

**20. (a)**

**21. (9.5) :** For buffer solution,

$$pH = pK_a + \log\left[\frac{Salt}{Acid}\right] = 4.5 + \log\left[\frac{Salt}{Acid}\right]$$

As *HA* is 50% ionised, hence [Salt] = [acid]

pH = 4.5 $\Rightarrow$ pOH = 14 – 4.5 = 9.5

**22. (4):**

$$\underset{\text{Conc.:}}{BaSO_4} \rightleftharpoons \underset{1 \times 10^{-4}}{Ba^{2+}} + \underset{s}{SO_4^{2-}}$$

$K_{sp} = 4 \times 10^{-10}$; $4 \times 10^{-10} = 1 \times 10^{-4} \times s$

$$s = \frac{4 \times 10^{-10}}{1 \times 10^{-4}} = 4 \times 10^{-6}\text{M}$$

**23. (5) :** $Mg(OH)_2 \rightleftharpoons \underset{s}{Mg^{2+}} + \underset{2s}{2OH^-}$

pH of $Mg(OH)_2$ solution is 10.

$\therefore$ pOH = 4; So, $[OH^-] = 10^{-4}$

$[OH^-] = 2 \times$ solubility

$$\therefore \quad \text{Solubility} = \frac{10^{-4}}{2} = 0.5 \times 10^{-4} = 5 \times 10^{-5} \text{ mol L}^{-1}$$

**24. (0.66) :**

$$A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$$

| | | | |
|---|---|---|---|
| Initial moles | 2 | 4 | 0 |
| Moles at eq. | $2 - x$ | $4 - x$ | $2x$ |

$$K_c = \frac{4x^2}{(2-x)(4-x)} = 4 \Rightarrow x = 1.33 \text{ mole}$$

$$[AB_{(g)}] = \frac{2 \times 1.33}{4} = 0.66\text{ M}$$

**25. (1) :** $K_{sp} = [Zn^{2+}][S^{2-}]$

$$[S^{2-}] = \frac{10^{-21}}{0.01} = 10^{-19}$$

$$H_2S \rightleftharpoons H^+ + HS^-;\ K_{a_1} = \frac{[H^+][HS^-]}{[H_2S]}$$

$$HS^- \rightleftharpoons H^+ + S^{2-};\ K_{a_2} = \frac{[H^+][S^{2-}]}{[HS^-]}$$

$$K_{a_1} \cdot K_{a_2} = \frac{[H^+]^2[S^{2-}]}{[H_2S]};\ 10^{-20} = \frac{[H^+]^2 \times 10^{-19}}{0.1}$$

$\Rightarrow \quad [H^+] = 0.1$ or pH = 1

# CBSE warm-up!

CLASS-XI

**Chapterwise practice questions for CBSE Exams as per the latest pattern and reduced syllabus by CBSE for the academic session 2022-23.**

**Series-5**

## Redox Reactions | Organic Chemistry- Some Basic Principles and Techniques

Time Allowed : 3 hours
Maximum Marks : 70

### GENERAL INSTRUCTIONS

***Read the following instructions carefully.***

*(a) There are 35 questions in this question paper with internal choice.*
*(b) SECTION A consists of 18 multiple-choice questions carrying 1 mark each.*
*(c) SECTION B consists of 7 very short answer questions carrying 2 marks each.*
*(d) SECTION C consists of 5 short answer questions carrying 3 marks each.*
*(e) SECTION D consists of 2 case- based questions carrying 4 marks each.*
*(f) SECTION E consists of 3 long answer questions carrying 5 marks each.*
*(g) All questions are compulsory.*
*(h) Use of log tables and calculators is not allowed.*

### SECTION A

**The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.**

**1.** Highest oxidation state of Mn is present in
(a) $KMnO_4$ (b) $K_2MnO_4$
(c) $Mn_2O_3$ (d) $MnO_2$

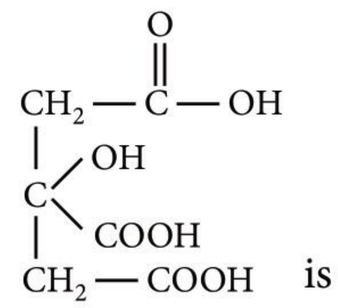
**2.** Chemical formula of Prussian blue is
(a) $Na_4[Fe(CN)_6]$ (b) $K_4[Fe(CN)_6]$
(c) $Fe_4[Fe(CN)_6]_3$ (d) None of these.

**3.** The element that does not severally show positive oxidation state is
(a) Mg (b) Na (c) Ca (d) F.

**4.** Among the following, the true property about $H_3C \diagdown \overset{+}{C} - CH_3$ is $H_3C \diagup$
(a) non-polar
(b) $sp^2$-hybridised
(c) electrophile can attack $C^+$
(d) does not undergo hydrolysis.

**5.** In which of the following compounds, the carbon marked with asterisk is expected to have greatest positive charge?
(a) $\overset{*}{C}H_3-CH_2-Cl$ (b) $\overset{*}{C}H_3-CH_2-Mg^+Cl^-$
(c) $\overset{*}{C}H_3-CH_2-Br$ (d) $\overset{*}{C}H_3-CH_2-CH_3$

**6.** The IUPAC name of the compound



is
(a) 1,2,3-tricarboxy-2,1-propane
(b) 3-carboxy-3-hydroxy-1,5-pentanedioic acid
(c) 3-hydroxy-3-carboxy-1,5-pentanedioic acid
(d) None of these.

**7.** $aC_2H_{6(g)} + nO_2 \rightarrow bCO_{2(g)} + mH_2O_{(l)}$
In this equation, ratio of the coefficients of $CO_2$ and $H_2O$ is
(a) 1 : 1 (b) 2 : 3 (c) 3 : 2 (d) 1 : 3

8. Stability of alkyl carbocations can be explained by
(a) inductive effect only
(b) hyperconjugation only
(c) both inductive effect and hyperconjugation
(d) electromeric effect only.

9. Amongst the given reactions, redox reaction is
(a) $C + O_2 \longrightarrow CO_2$
(b) $2NaH \xrightarrow{\Delta} 2Na + H_2$
(c) $Fe + 2HCl \longrightarrow FeCl_2 + H_2$
(d) All of these.

10. In which of the following pairs, there is maximum difference in the oxidation number of the underlined elements?
(a) $\underline{N}O_2$ and $\underline{N}_2O_4$ (b) $\underline{P}_2O_5$ and $\underline{P}_4O_{10}$
(c) $\underline{N}_2O$ and $\underline{N}O$ (d) $\underline{S}O_2$ and $\underline{S}O_3$

11. The bond order of individual carbon-carbon bonds in benzene is
(a) one (b) two
(c) between one and two
(d) one and two alternately.

12. In the standardization of $Na_2S_2O_3$ using $K_2Cr_2O_7$ by iodometry, the equivalent weight of $K_2Cr_2O_7$ is
(a) (Molecular weight)/2
(b) (Molecular weight)/6
(c) (Molecular weight)/3
(d) same as molecular weight.

13. The non existence of $PbI_4$ and $PbBr_4$ is due to
(a) highly oxidizing nature of $Pb^{4+}$ ions
(b) highly reducing nature of $I^-$ and $Br^-$ ions
(c) larger size of $Pb^{4+}$, $Br^-$ and $I^-$ ions
(d) both (a) and (b).

14. Empirical formula of a compound is $CH_2O$ and its molecular mass is 90, the molecular formula of the compound is
(a) $C_3H_6O_3$ (b) $C_2H_4O_2$
(c) $C_6H_{12}O_6$ (d) $CH_2O$

15. Given below are two statements labelled as Assertion (A) and Reason (R).
**Assertion (A) :** The decomposition of hydrogen peroxide to form water and oxygen is an example of disproportionation reaction.
**Reason (R) :** The oxygen of peroxide is in –1 oxidation state and it is converted to zero oxidation state in $O_2$ and –2 oxidation state in $H_2O$.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

16. Given below are two statements labelled as Assertion (A) and Reason (R).
**Assertion (A) :** Components of a mixture of red and blue inks can be separated by distributing the components between stationary and mobile phases in paper chromatography.
**Reason (R) :** The coloured components of inks migrate at different rates because paper selectively retains different components according to the difference in their partition between the two phases.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

17. Given below are two statements labelled as Assertion (A) and Reason (R).
**Assertion :** In the representation,
$E^\circ_{Fe^{3+}/Fe^{2+}}$ and $E^\circ_{Cu^{2+}/Cu}$,
$Fe^{3+}/Fe^{2+}$ and $Cu^{2+}/Cu$ are redox couples.
**Reason :** Redox couple is the combination of oxidised and reduced form of a substance involved in an oxidation or reduction half cell.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

18. Given below are two statements labelled as Assertion (A) and Reason (R).
**Assertion (A) :** Energy of resonance hybrid is equal to the average of energies of all canonical forms.
**Reason (R) :** Resonance hybrid cannot be presented by a single structure.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

## SECTION B

**This section contains 7 questions with internal choice in two questions. The following questions are very short answer type and carry 2 marks each.**

**19.** Find the oxidation number of underlined elements:
**(a)** $K_2\underline{Mn}O_4$ **(b)** $KAl(\underline{S}O_4)_2.12H_2O$

**20.** Draw structures of
**(a)** 3, 4-dimethylphenol **(b)** 6-hydroxyheptanal.

**OR**

In Carius method of estimation of halogen, 0.15 g of an organic compound gave 0.12 g of AgBr. Find out the % of Br in the compound.
(At. mass of Ag = 108, Br = 80)

**21.** Explain the statement 'oxidation and reduction are reciprocal'.

**OR**

Balance the following equation in basic medium by ion-electron method :

$$P_{4(s)} + OH^-_{(aq)} \longrightarrow PH_{3(g)} + H_2PO^-_{2(aq)}$$

**22.** An iron rod is immersed in solution containing 1.0 M $NiSO_4$ and 1.0 M $ZnSO_4$. Predict giving reasons which of the following reactions is likely to proceed.
**(a)** Fe reduces $Zn^{2+}$ ions
**(b)** Fe reduces $Ni^{2+}$ ions.
(Given : $E°_{Zn^{2+}/Zn} = -0.76$ V, $E°_{Fe^{2+}/Fe} = -0.44$ V and $E°_{Ni^{2+}/Ni} = -0.25$ V)

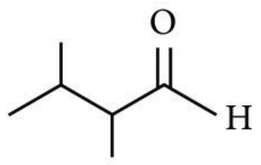
**23.** **(a)** Mention the type of hybridisation of each carbon in the compound $CH_3—CN$.
**(b)** Draw the structure of 2-methylpropan-2-ol.

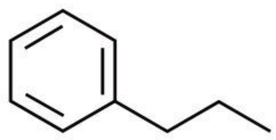
**24.** Identify the oxidant and reductant in the following reactions:

**(a)** $Zn_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow ZnO_{(s)}$

**(b)** $Zn_{(s)} + 2H^+_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + H_{2(g)}$

**25.** Give IUPAC name of the following compounds.

**(a)** 


**(b)** 

## SECTION C

**This section contains 5 questions with internal choice in two questions. The following questions are short answer type and carry 3 marks each.**

**26.** Give the balanced equations for the reactions that form the basis for the following redox titrations :
**(a)** titration of potassium permanganate for estimation of ferrous ions.
**(b)** titration of iodine against sodium thiosulphate (iodometric titration).
**(c)** iodometric titration for estimation of cupric ions.

**27.** The following techniques are used to quantitatively estimate extra elements in organic compound. Identify the name of the method and the element estimated by this method.
**(a)** A known mass of an organic compound is heated with fuming $HNO_3$ in presence of $AgNO_3$.
**(b)** Organic compound is heated with dry copper oxide in atmosphere of $CO_2$.
**(c)** Organic compound is heated with conc. $H_2SO_4$.

**OR**

**(a)** Define hyperconjugation effect. Explain why $(CH_3)_3C^+$ is more stable than $CH_3CH_2^+$.
**(b)** Identify the nucleophiles from the following : $R_3N$, $BF_3$, $RMgX$, $NC^-$.

**28.** **(a)** Balance the following redox reaction by ion-electron method.
$MnO_4^- + SO_2 \rightarrow Mn^{2+} + HSO_4^-$ (acidic medium)
**(b)** Identify the oxidant and reductant in the following reaction :
$2K_4[Fe(CN)_6]_{(aq)} + H_2O_{2(aq)} \rightarrow 2K_3[Fe(CN)_6]_{(aq)} + 2KOH_{(aq)}$

**29.** How are free radicals, carbocations and carbanions produced? Explain.

**30.** Give reasons for **any three** of the following:
**(i)** Iron undergoes oxidation more readily than copper.
**(ii)** In an electrochemical cell, an electrode with lower electrode potential acts as a reducing agent.
**(iii)** When a copper rod is placed in silver nitrate solution, the solution becomes hot but the reverse is not true.
**(iv)** Iron reacts with dilute $H_2SO_4$ to evolve $H_2$ gas but Ag does not.

## SECTION D

**The following questions are case-based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.**

**31.** Oil India Company is refining petroleum by fractional distillation. It gives petrol, diesel, kerosene and fuel oil which are most useful in transportation and for domestic purposes. Petro-products are the sources of lot of pollution. Use of CNG and LPG can reduce pollution to some extent. Unleaded petrol, speed petrol and turbo diesel

also reduce pollution. Oil Inida is producing high quality petrol and diesel so as to reduce pollution.

**Answer the following questions :**

**(a)** Why should we use less petro-products?

**(b)** What is the advantage of unleaded petrol?

**(c)** What are advantages of speed/power/premium petrol and turbo diesel?

**OR**

What are the values possessed by Oil India Company?

**32.** Sonali was discussing a very interesting topic of chemistry 'Redox reactions' with her friend Geeta in the class and planned to search day-to-day life processes which are based on these reactions. They both went home and did their work and made project file. Next day they exchanged their information and were amazed how 'Redox reactions' play major role in our daily life.

**Answer the following questions :**

**(a)** Give one example of redox reactions that occur in human and plant body each.

**(b)** Is rusting or corrosion a 'redox reaction'? What is electroplating?

**(c)** Can we store copper sulphate in an iron vessel? Give reason for your answer.

**OR**

The colour of KI solution containing starch turns blue when it is shaken with cold $Cl_2$ water. Explain why?

## SECTION E

**The following questions are long answer type and carry 5 marks each. Two questions have an internal choice.**

**33. (a)** Suggest a method used to purify the liquids which have high boiling points and decompose below their boiling points.

**(b)** How will you separate a mixture of ammonium chloride and common salt?

**(c)** Will $CCl_4$ give white precipitate of AgCl on heating with silver nitrate? Give reason for your answer.

**(d)** In the estimation of sulphur, 0.157 g of an organic compound gave 0.4813 g of $BaSO_4$. What is the percentage of sulphur in the compound?
(At. wt. of Ba = 137, S = 32, O = 16 u)

**OR**

0.45 g of an organic compound gave 0.792 g of $CO_2$ and 0.324 g of water on combustion. 0.24 g of same substance was Kjedahlised and the $NH_3$ formed was absorbed in 50.0 $cm^3$ of $\frac{M}{8}$ $H_2SO_4$. The excess acid required 77.0 $cm^3$ of $\frac{M}{10}$ NaOH for complete neutralisation. Calculate the empirical formula of the compound.

**34. (a)** Balance the following unbalanced equation (in acidic medium) by ion-electron method (half-reaction method).

$$Mn^{2+}_{(aq)} + ClO^{-}_{3(aq)} \longrightarrow MnO_{2(s)} + ClO_{2(aq)}$$

**(b)** Explain why sulphur dioxide can act both as an oxidant and reductant but nitric acid can act only as an oxidant.

**(c)** What do you understand by disproportionation reaction?

**OR**

Using oxidation number concept, identify the redox reactions. Identify oxidising and reducing agents in case of redox reactions.

**(a)** $H_3PO_{4(aq)} + 3KOH_{(aq)} \longrightarrow K_3PO_{4(aq)} + 3H_2O_{(l)}$

**(b)** $Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$

**(c)** $6Fe^{2+}_{(aq)} + BrO^{-}_{3(aq)} + 6H^{+}_{(aq)} \longrightarrow 6Fe^{3+}_{(aq)} + Br^{-}_{(aq)} + 3H_2O_{(l)}$

**(d)** $2Zn_{(s)} + O_{2(g)} \longrightarrow 2ZnO_{(s)}$

**(e)** $Sn^{2+}_{(aq)} + IO^{-}_{4(aq)} \longrightarrow Sn^{4+}_{(aq)} + I^{-}_{(aq)}$

**35.** Give condensed and bond-line structural formulae for the following and identify the functional group(s) present (if any).

**(a)** 2, 2,4-trimethylpentane,

**(b)** 2-hydroxy-1, 2, 3-propanetricarboxylic acid,

**(c)** cycloocta-1, 5-diene,

**(d)** hexandial,

**(e)** 2-(4-*iso*-butylphenyl) propanoic acid.

## SOLUTIONS

**1. (a)**

**2. (c) :** $Fe^{2+}$ ions are oxidized to $Fe^{3+}$ which reacts with sodium ferrocyanide to give ferriferrocyanide which is Prussian blue in colour.

$$4Fe^{3+} + 3Na_4[Fe(CN)_6] \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 12Na^+$$

**3. (d)** **4. (b)** **5. (a)** **6. (b)**

**7. (b) :** The balanced equation is,

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

Ratio of the coefficients of $CO_2$ and $H_2O$ is 4 : 6 or 2 : 3.

**8. (c)** **9. (d)** **10. (d)** **11. (c)**

**12. (b) :** $K_2Cr_2O_7$ acts as an oxidising agent in presence of dil. $H_2SO_4$.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

Equivalent weight of $K_2Cr_2O_7$

$$= \frac{\text{Molecular weight}}{\text{Number of electrons gained}} = \frac{M}{6}$$

**13. (d)** **14. (a)** **15. (a)** **16. (a)**

**17. (a)** **18. (d)**

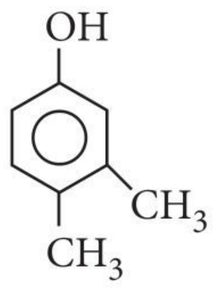
**19. (a)** Let the oxidation number of Mn in $K_2MnO_4$ be $x$.

$2 \times (+1) + x + (-2) \times 4 = 0 \quad \Rightarrow \quad x = +6$

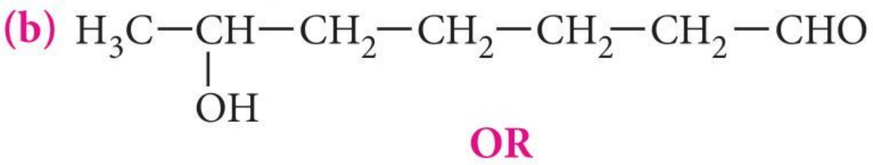
**(b)** Let the oxidation number of S in $KAl(SO_4)_2.12H_2O$ be $x$.

$\therefore \quad +1 + 3 + 2x - 16 + 0 = 0 \quad \Rightarrow \quad 2x - 12 = 0 \quad \Rightarrow \quad x = +6$

**20. (a)**



**(b)**



**OR**

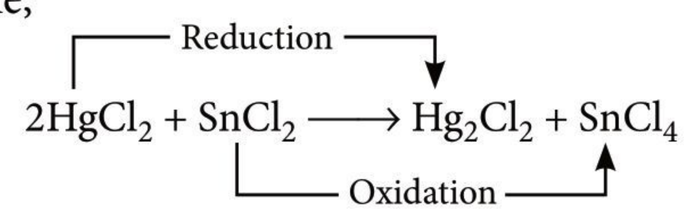
Molar mass of AgBr = 108 + 80 = 188 g $mol^{-1}$

188 g AgBr contains 80 g bromine.

0.12 g AgBr contains $\frac{80 \times 0.12}{188}$ g bromine.

Percentage of bromine = $\frac{80 \times 0.12 \times 100}{188 \times 0.15} = 34.04\ \%$

**21.** Oxidation and reduction always take place simultaneously. In the following example, one substance is oxidised and other is reduced at the same time. Example,




$HgCl_2$ is reduced to $Hg_2Cl_2$, and $SnCl_2$ is oxidised to $SnCl_4$.

**OR**

$$\overset{0}{P}_{4(s)} + OH^-_{(aq)} \longrightarrow \overset{-3}{P}H_{3(g)} + H_2\overset{+1}{P}O^-_{2(aq)}$$

Oxidation half-reaction,

$$P_4 + 8OH^- \longrightarrow 4H_2PO_2^- + 4e^- \qquad \ldots(i)$$

Reduction half-reaction,

$$12e^- + 12H_2O_{(aq)} + P_{4(s)} \longrightarrow 4PH_{3(g)} + 12OH^- \qquad \ldots(ii)$$

On multiplying equation (i) by 3 and adding it to equation (ii), we have balanced equation:

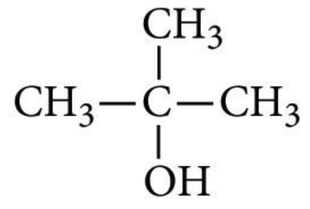
$$3H_2O_{(l)} + P_{4(s)} + 3OH^- \longrightarrow 3H_2PO^-_{2(aq)} + PH_{3(g)}$$

**22. (a)** Since, $E°$ of Zn is more negative than that of Fe, therefore, Zn will be oxidised to $Zn^{2+}$ ions while $Fe^{2+}$ ions will be reduced to Fe. In other words, Fe will not reduce $Zn^{2+}$ ions.

**(b)** Since, $E°$ of Fe is more negative than that of Ni, therefore, Fe will be oxidised to $Fe^{2+}$ ions while $Ni^{2+}$ ions will be reduced to Ni. Thus, Fe reduces $Ni^{2+}$ ions.

**23. (a)** $\overset{2}{C}H_3-\overset{1}{C}\equiv N$, 1st carbon is '*sp*' and 2nd carbon is $sp^3$ hybridised.

**(b)**



2-Methylpropan-2-ol

**24. (a)** Zn is reducing agent (reductant) and $O_2$ is an oxidising agent (oxidant).

**(b)** Zn is reducing agent (reductant), whereas $H^+$ is an oxidising agent (oxidant).

**25. (a)** IUPAC name : 2, 3-Dimethylbutanal

**(b)** IUPAC name : 1-Phenylpropane

**26. (a)** $5Fe^{2+}_{(aq)} + MnO^-_{4(aq)} + 8H^+_{(aq)} \longrightarrow 5Fe^{3+}_{(aq)} + Mn^{2+}_{(aq)} + 4H_2O_{(l)}$

**(b)** $I_{2(aq)} + 2S_2O^{2-}_{3(aq)} \longrightarrow 2I^-_{(aq)} + S_4O^{2-}_{6(aq)}$

**(c)** $2Cu^{2+}_{(aq)} + 4I^-_{(aq)} \longrightarrow Cu_2I_{2(s)} + I_{2(s)}$

**27. (a)** Estimation of halogen by Carius method.

**(b)** Estimation of nitrogen by Dumas method.

**(c)** Estimation of nitrogen by Kjeldahl's method.

**OR**

**(a)** Hyperconjugation involves delocalisation of σ electrons of C—H bond of an alkyl group directly attached to an atom of unsaturated system or $sp^2$ hybrid carbon. Hyperconjugative interaction in $(CH_3)_3C^+$ is greater than that in $CH_3CH_2^+$ as $(CH_3)_3C^+$ has nine C—H bonds.

**(b)** *R*Mg*X*, $R_3N$ and $NC^-$

**28. (a)** $MnO_4^- + SO_2 \rightarrow Mn^{2+} + HSO_4^-$(acidic medium)

$$[5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O] \qquad \ldots(i)$$

$$[2H_2O + SO_2 \rightarrow HSO_4^- + 3H^+ + 2e^-] \qquad \ldots(ii)$$

$$H^+ + 2MnO_4^- + 5SO_2 + 2H_2O \rightarrow 2Mn^{2+} + 5HSO_4^-$$

**(b)** $K_4[Fe(CN)_6]$ acts as a reducing agent as oxidation number of Fe is changed from +2 to +3 and $H_2O_2$ act as an oxidising agent as oxidation number of oxygen is changed from –1 to –2.

**29.** Free radicals are produced by homolytic fission, *e.g.*;

$$Cl\!-\!Cl \xrightarrow{\text{Sunlight}} \underset{\text{Chlorine free radical}}{2Cl^{\bullet}}$$

Carbocations are formed by heterolytic fission, *e.g.*;

$$CH_3\!-\!Cl \longrightarrow \overset{+}{C}H_3 + Cl^-$$

Carbanions are formed by abstraction of $H^+$ by nucleophile from α-carbon (carbon attached to functional group).

$$CH_3CHO + OH^- \longrightarrow \underset{\text{Carbanion}}{\bar{C}H_2\!-\!\overset{\overset{O}{\|}}{C}\!-\!H} + H_2O$$

**30. (i)** The electrode potential of iron,
(*i.e.*, $E^\circ_{Fe^{2+}/Fe} = -0{\cdot}44$ V) is lower than that of copper (*i.e.*, $E^\circ_{Cu^{2+}/Cu} = +0{\cdot}34$ V) and hence Fe has greater tendency to get converted into $Fe^{2+}$ ions than Cu. In other words, iron undergoes oxidation more readily than copper.

**(ii)** An electrode with lower electrode potential has more tendency to get oxidised. In other words, it has more tendency to release electrons, and hence acts as a reducing agent.

**(iii)** Copper ($E^\circ_{Cu^{2+}/Cu} = +0{\cdot}34$ V) has lower electrode potential than silver ($E^\circ_{Ag^+/Ag} = +0.80$ V). Therefore, Cu releases electrons and gets oxidised to $Cu^{2+}$ ions while $Ag^+$ ions accept these electrons and get reduced to Ag metal.

$$Cu_{(s)} + 2Ag^+_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$$

The chemical energy of this reaction appears as heat and hence the solution becomes hot.

Since, the reverse reaction cannot occur (because the $E^\circ$ of Ag is higher than that of Cu).

Therefore, no change is observed.

**(iv)** Fe has lower electrode potential ($E^\circ_{Fe^{2+}/Fe} = -0.44$ V) than that of hydrogen ($E^\circ_{H^+/H_2} = 0.0$ V), therefore, Fe is a better reducing agent than $H_2$ and hence reduces $H^+$ ions to produce $H_2$ gas.

$$Fe_{(s)} + 2H^+_{(aq)} \longrightarrow Fe^{2+}_{(aq)} + H_{2(g)}$$

In contrast, Ag has higher electrode potential ($E^\circ_{Ag^+/Ag} = 0.80$ V) than hydrogen. Therefore, $H_2$ is a better reducing agent than Ag. In other words, Ag cannot reduce $H^+$ ions to produce $H_2$ gas.

**31. (a)** It is because they are the sources of air pollution and we have to import a lot of oil which needs lot of foreign currency.

**(b)** It prevents pollution due to lead.

**(c)** They are refined to more extent and undergo almost complete combustion and create less pollution.

**OR**

They are helping to reduce pollution by improving quality of diesel and petrol.

**32. (a)** Photosynthesis and respiration are two examples of redox reactions occurring in plant and human body respectively.

$$6CO_2 + 6H_2O + \text{Energy (Sunlight)} \xrightarrow[\text{Photosynthesis}]{\text{Chlorophyll}} \underset{\text{Glucose}}{C_6H_{12}O_6} + 6O_2$$

Like photosynthesis, respiration is also a redox reaction in which, glucose is oxidised to $CO_2$ and $O_2$ is reduced to $H_2O$.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + 6\,O_2 \xrightarrow{\text{Respiration}} 6\,CO_2 + 6\,H_2O + \text{Energy}$$

**(b)** Corrosion (rusting) is a redox reaction. The deposition of one metal over another through electrolysis is called electroplating.

**(c)** No, because iron is more reactive than copper, and therefore, it will displace copper from its salt solution.

$$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$$

**OR**

$Cl_2$ is stronger oxidizing agent than $I_2$, therefore, when $Cl_2$ is passed through KI solution, $Cl_2$ gets reduced to $Cl^-$ ions while $I^-$ ions get oxidised to violet coloured iodine according to the equation,

$$Cl_{2(aq)} + 2I^-_{(aq)} \longrightarrow 2Cl^-_{(aq)} + I_{2(s)}$$

The iodine thus produced forms a blue coloured inclusion complex with starch and hence the solution turns blue.

**33. (a)** Distillation under reduced pressure

**(b)** Sublimation

**(c)** No, it is because $CCl_4$ is non-polar covalent compound, does not give $Cl^-$ therefore does not react with $AgNO_3$ solution.

**(d)** $$\%\text{ of S} = \frac{32}{233} \times \frac{\text{Wt. of } BaSO_4}{\text{Wt. of organic compound}} \times 100$$

$$= \frac{32}{233} \times \frac{0.4813}{0.157} \times 100 = 42.10\%$$

**OR**

$$\%\text{ of C} = \frac{12}{44} \times \frac{0.792}{0.45} \times 100 = 48\%$$

$$\%\text{ of H} = \frac{2}{18} \times \frac{0.324}{0.45} \times 100 = 8\%$$

$$\underset{(NaOH)}{M_1V_1} = \underset{(H_2SO_4)}{2M_2V_2} \Rightarrow \frac{1}{10} \times 77 = 2 \times \frac{1}{8} \times V_2 \Rightarrow V_2 = 30.8\,cm^3$$

Volume of $\frac{M}{8}$ $H_2SO_4$ consumed by $NH_3 = 2(50 - 30.8)$
$= 2 \times 19.2\ cm^3$

$19.2\ cm^3$ of $\frac{M}{8}$ $H_2SO_4 = 2 \times 19.2\ cm^3$ of $\frac{M}{8}$ $NH_3$

$$\% \text{ of } N = \frac{1.4 \times 2 \times V_1 \times M_1}{W} = \frac{1.4 \times 2 \times 19.2 \times 1}{0.24 \times 8} = 28\%$$

| Element | % | Atomic weight | Relative no. of atoms | Divided by least | Simplest ratio |
|---|---|---|---|---|---|
| C | 48 | 12 | 48/12 = 4 | 4/1 = 4 | 4 |
| H | 8 | 1 | 8/1 = 8 | 8/1 = 8 | 8 |
| N | 28 | 14 | 28/14 = 2 | 2/1 = 2 | 2 |
| O | 16 | 16 | 16/16 = 4 | 1/1 = 1 | 1 |

Empirical formula = $C_4H_8N_2O$

**34. (a)** The equation is balanced in terms of number of atoms and the charges. Hence, balanced equation is :

$$Mn^{2+}_{(aq)} + 2ClO^-_{3(aq)} \longrightarrow MnO_{2(s)} + 2ClO_{2(aq)}$$

**(b)** In $SO_2$, the O.N. of S is +4. In principle, S can have a minimum oxidation state of –2 and a maximum of +6. Therefore, when O.N. of sulphur decreases, it acts as an oxidising agent and when it increases, it acts as a reducing agent. In $HNO_3$, N exists in its highest oxidation state of +5. Therefore, it can only decrease its O.N. and hence, it acts as an oxidising agent only.

**(c)** A reaction in which a particular species simultaneously gets oxidised and reduced, is known as disproportionation reaction.

$$\overset{+1}{Hg_2Cl_2} \longrightarrow \overset{0}{Hg} + \overset{+2}{HgCl_2}$$

In this reaction, $Hg_2Cl_2$ is getting oxidised to $HgCl_2$ and also getting reduced to Hg.

**OR**

**(a)** As oxidation numbers are not changing of any element hence, the given reaction is not a redox reaction.

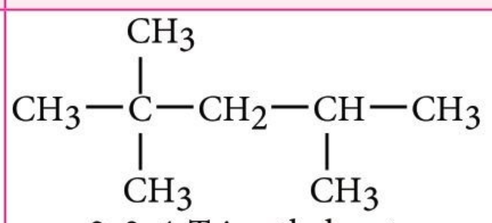
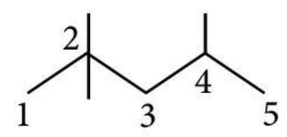
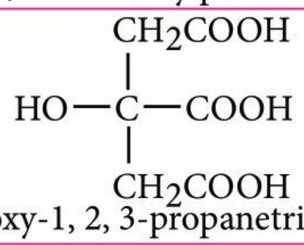
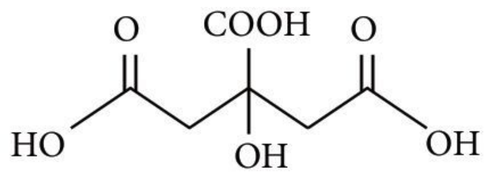
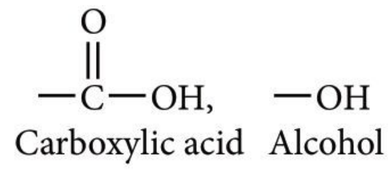
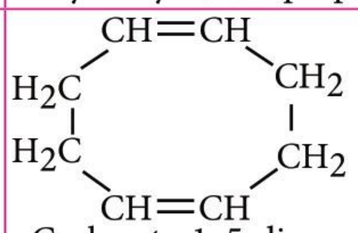
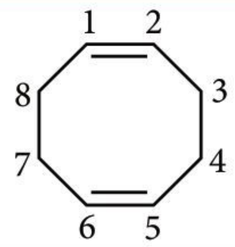
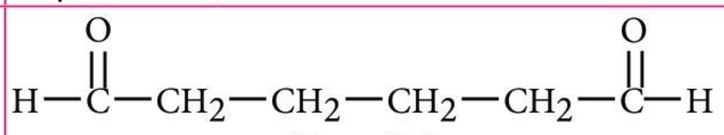
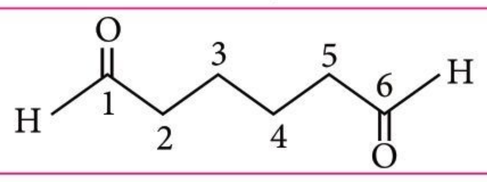
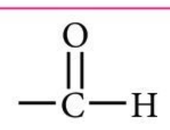
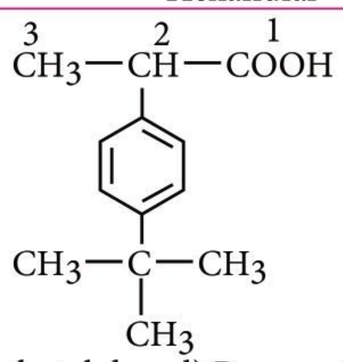
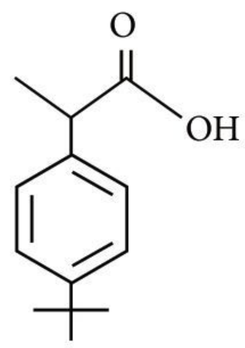
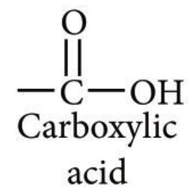
**(b)** The given reaction is a redox reaction.
Oxidant/oxidising agent : HCl.
Reductant/reducing agent : Zn

**(c)** The given reaction is a redox reaction.
Oxidant/oxidising agent : $BrO_3^-$
Reductant/reducing agent : $Fe^{2+}$

**(d)** The given reaction is a redox reaction.
Oxidant/oxidising agent : $O_2$
Reductant/reducing agent : Zn

**(e)** The given reaction is a redox reaction.
Oxidant/oxidising agent : $IO_4^-$
Reductant/reducing agent : $Sn^{2+}$

**35.**

| | Condensed formula | Bond-line formula | Functional group |
|---|---|---|---|
| **(a)** |  2, 2, 4-Trimethylpentane |  | No functional group, single bonds |
| **(b)** |  2-Hydroxy-1, 2, 3-propanetricarboxylic acid |  |  Carboxylic acid Alcohol |
| **(c)** |  Cycloocta-1, 5-diene |  | Double bonds |
| **(d)** |  Hexandial |  |  Aldehyde |
| **(e)** |  2-(4-*iso*-butylphenyl) Propanoic acid |  |  Carboxylic acid |

# CONCEPT MAP

# ELECTROCHEMISTRY | CHEMICAL KINETICS

## ELECTROCHEMISTRY

**CELL**
(Device to convert chemical energy to electrical energy or vice-versa)

**Electrochemical cell or Galvanic cell convert chemical energy to electrical energy**

**Electrolytic cell convert electrical energy to chemical energy**

Flow of current is opposite to the flow of electrons.

**Electrode Potential :** It is defined as the tendency of an electrode to either lose or gain electrons.

**Cell Potential :** The difference between electrode potentials of two half cells is called cell potential or cell voltage or electromotive force (EMF) of the cell.

**EMF of cell :** $E^\circ_{cell} = E^\circ_{right} - E^\circ_{left} = E^\circ_{cathode} - E^\circ_{anode}$ (in terms of standard reduction electrode potential).

### Nernst Equation and Electrochemical Series

**Nernst equation :** For the reaction :

$$M^{n+} + ne^- \rightarrow M,\ E = E^\circ - \frac{RT}{nF}\ln\frac{M}{[M^{n+}]} \text{ or}$$

$$E = E^\circ - \frac{0.0591}{n}\log\frac{1}{[M^{n+}]} \text{ at } 298\ K$$

$$E^\circ_{cell} = \frac{2.303\,RT}{nF}\log K \text{ (at equilibrium, } E_{cell} = 0)$$

$$\Delta G^\circ = -nFE^\circ_{cell},\ \Delta G^\circ = -RT\ln K$$

**Electrochemical series :** Elements arranged in increasing or decreasing order of their standard electrode potential.

$F_2 > Co^{3+} > Ag^+ > Cu^{2+} > Cr^{3+} > K^+ > Li^+$

Decreasing order of reduction electrode potential.

or

Decreasing order of oxidising power.

**Uses :** Electrochemical cells are extensively used for determining the pH of solution, solubility product, equilibrium constant and for potentiometric titrations.

Conductance of electricity through electrolytic solution.

$$R = \frac{\rho l}{A};\ G = \frac{1}{R};\ \kappa = \frac{1}{\rho} = \frac{l}{RA}$$

Measurement of conductivity of ionic solution using conductivity cell.

**Cell constant ($G^*$) :** $G^* = \frac{l}{A} = R\kappa$, So, $\kappa = \frac{\text{Cell constant}}{R}$

**Molar Conductivity ($\Lambda_m$) :** $\Lambda_m = \frac{\kappa}{C} \times 1000$

**Variation of conductivity with concentration:** Conductivity decreases with decrease in concentration for both weak and strong electrolyte.

### Variation of molar conductivity

**For a strong electrolyte:** On dilution, there is only small increase in conductance.

**For a weak electrolyte:** On dilution, there is large increase in conductance especially near infinite dilution.

**Limiting molar conductivity ($\Lambda^\circ_m$):** When concentration approaches zero.

**Kohlrausch's law of independent migration:**

$M_xN_y \longrightarrow xM^{y+} + yN^{x-};\ \Lambda^\circ_m = x\lambda_{M^{y+}} + y\lambda_{N^{x-}}$

**For weak electrolyte:** $\alpha = \frac{\Lambda_m}{\Lambda^\circ_m}$

$$K_a = \frac{C\alpha^2}{1-\alpha} = \frac{C\Lambda_m^2}{\Lambda^\circ_m(\Lambda^\circ_m - \Lambda_m)}$$

**Electrolysis:** Faraday 1st law of electrolysis:

$w \propto Q;\ w \propto It;\ w = ZIt$

($w$ = weight of substance deposited/discharged at any electrode, Z = electrochemical equivalent.)

2nd Law of electrolysis: $\frac{w_I}{w_{II}} = \frac{\text{Eq. } wt_1}{\text{Eq. } wt_2}$

### Commercial Cells (Batteries)

Two or more galvanic cells connected in series is called battery. They are mainly primary batteries, secondary batteries and fuel cells.

## CHEMICAL KINETICS

### Rate of Reaction

It is defined as the change in concentration of any one of the reactant or product in unit time.

**Important Relations :**

For a reaction, $aA + bB \rightarrow xX + yY$

$$\text{Rate of reaction} = -\frac{1}{a}\frac{d[A]}{dt} = -\frac{1}{b}\frac{d[B]}{dt} = +\frac{1}{x}\frac{d[X]}{dt} = +\frac{1}{y}\frac{d[Y]}{dt}$$

But, rate of disappearance of $A = -\frac{d[A]}{dt} = a \times$ Rate of reaction

Rate of formation of $X = +\frac{d[X]}{dt} = n \times$ Rate of reaction

### Factors Affecting the Rate of a Reaction

- Concentration of reactants
- Presence of light
- Catalyst
- Surface area
- Temperature
- **Rate law expression :** $aA + bB \longrightarrow cC + dD$

  Rate $\propto [A]^x[B]^y$, $x$ and $y$ are different from '$a$' and '$b$'

  $R = k[A]^x[B]^y$

  $k$ = Rate constant

  Order of reaction = $x + y$

  Rate law cannot be decided by the chemical reaction and can be calculated experimentally.

| Order | Molecularity |
|---|---|
| • Experimentally determined. | • Theoretically calculated. |
| • Can be zero and even a fraction. | • Cannot be zero or integer. |
| • Applicable to elementary as well as complex reaction. | • Molecularity has no meaning for complex reaction. |

- **Rate constant :** It is equal to the rate of reaction when the concentration of each of the reactants is unity.

  Units of rate constant ($k$) for an $n^{th}$ order reaction :

  $k = (\text{conc.})^{1-n}\ \text{time}^{-1}$

**Pseudo first order reaction:** Change in concentration of one of the reactant is negligible, *e.g.*,

- Hydrolysis of ester
- Hydrolysis of sugar

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

$R = k[C_{12}H_{22}O_{11}][H_2O]$ {$[H_2O]$ is negligible.}

$k \cdot [H_2O] = K^*;\ R = k^*[C_{12}H_{22}OH_{11}]$

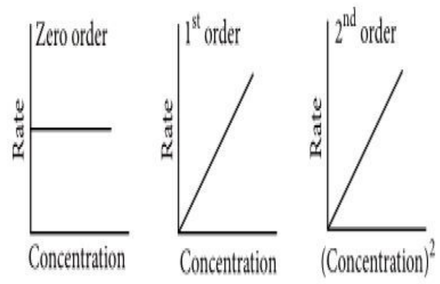
### Integrated Rate Law

For zero order : $k = \frac{1}{t}\{[A]_0 - [A]\};\ t_{1/2} = \frac{[A]_0}{2k_0}$

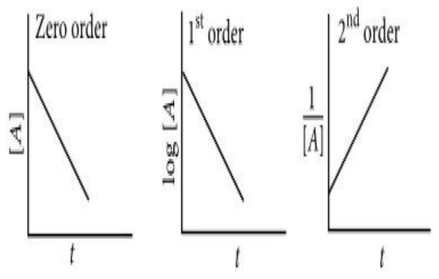
For first order : $k = \frac{2.303}{t}\log\left(\frac{a}{a-x}\right);\ t_{1/2} = \frac{0.693}{k_1}$

### Some Important Graphs of Different order of Reactions

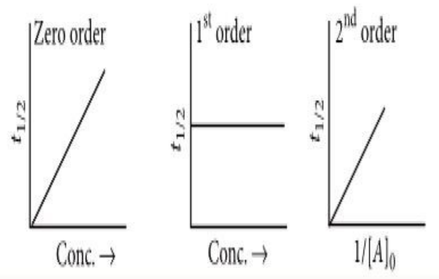
- Plots of rate *vs* concentration




- Plots of integrated rate equations




- Plots of half-lives *vs* initial concentration



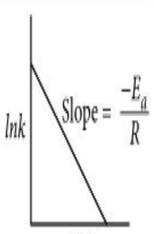

### Temperature Dependence on the Rate of a Reaction

**Collision theory :** $k = PZe^{-E_a/RT}$

where, $P$ = steric factor, Z = collision frequency

**Effective collision:** Collision with sufficient kinetic energy and proper orientation.

**Arrhenius equation :** Arrhenius proposed a quantitative relationship between rate constant and temperature as $k = Ae^{-E_a/RT}$




$$\ln k = \ln A - \frac{E_a}{RT};\ \log_{10} k = \log_{10} A - \frac{E_a}{2.303RT}$$

$$\log\frac{k_2}{k_1} = \frac{E_a}{2.303R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$$

**Catalyst:** Provide alternate path with lower activation energy.

- Does not alter Gibb's energy.
- Does not change equilibrium constant.

# MONTHLY TEST DRIVE

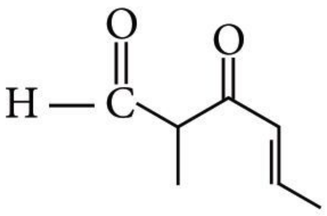
This specially designed column enables students to self analyse their extent of understanding the specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

**Total Marks : 120** **Organic Chemistry - Some Basic Principles and Techniques** **Time Taken : 60 Min.**

## NEET

### Only One Option Correct Type

**1.** The IUPAC name of the compound



is _____.

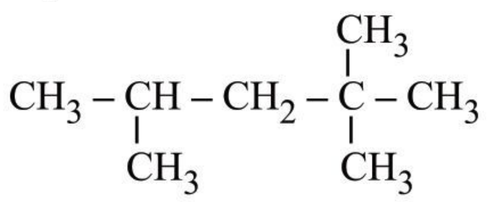
(a) 5-formylhex-2-en-3-one
(b) 5-methyl-4-oxohex-2-en-5-al
(c) 3-keto-2-methylhex-5-enal
(d) 3-keto-2-methylhex-4-enal

**2.** The order of decreasing stability of the following carbanions is

(i) $(CH_3)_3C^-$ (ii) $(CH_3)_2CH^-$
(iii) $CH_3CH_2^-$ (iv) $C_6H_5CH_2^-$

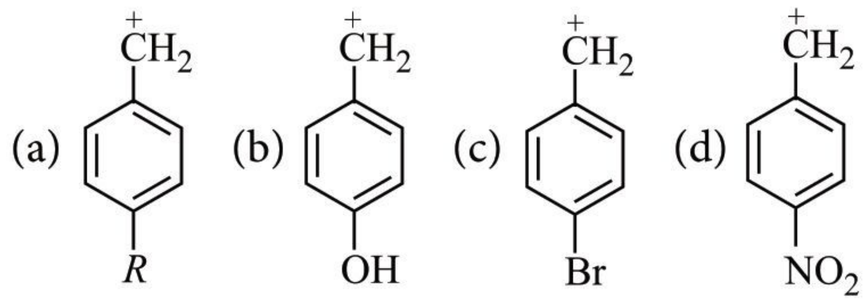
(a) (i) > (ii) > (iii) > (iv)
(b) (iv) > (iii) > (ii) > (i)
(c) (iv) > (i) > (ii) > (iii)
(d) (iii) > (ii) > (i) > (iv)

**3.** How many primary, secondary, tertiary and quarternary (if any) carbon atoms are present in the following compound?



(a) One primary, two secondary and one tertiary
(b) Five primary and three secondary
(c) Five primary, one secondary, one tertiary and one quarternary
(d) Four primary, two secondary and two quarternary.

**4.** Which carbocation is the least stable?

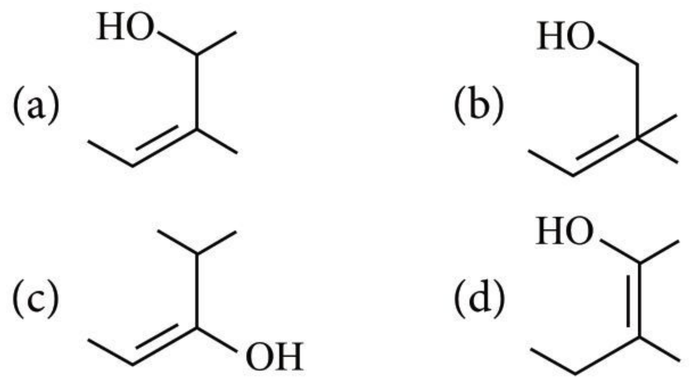


**5.** Which type of intermediate (*A*) is formed during the reaction?

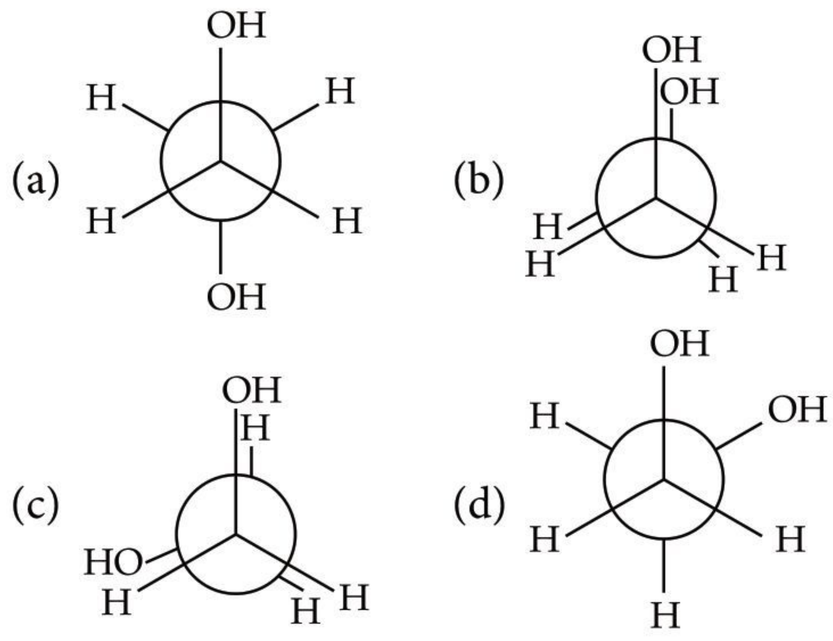
$$CH_3CH_2 - N{=}N - CH_2CH_3 \xrightarrow{Heat} (A) + N_2$$

(a) Carbocation (b) Carbanion
(c) Free radical (d) Carbene

**6.** Correct representation of 3-methylpent-3-en-2-ol is

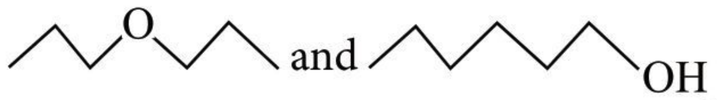


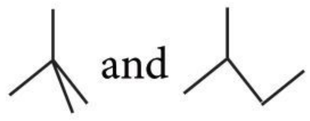
**7.** Which of the following conformers for ethylene glycol is most stable?

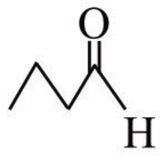


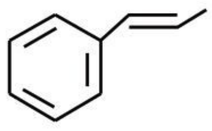
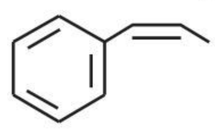
8. 0.765 g of an acid gives 0.535 g of $CO_2$ and 0.138 g of $H_2O$. Then the ratio of the percentage of carbon and hydrogen is
(a) 19 : 2 (b) 18 : 11 (c) 70 : 17 (d) 1 : 7

9. Which of the following pairs of compounds does not represent structural isomers?

(a)  and 

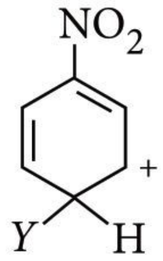
(b)  and 

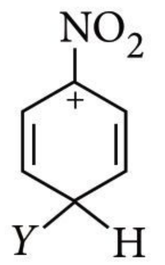
(c)  and 

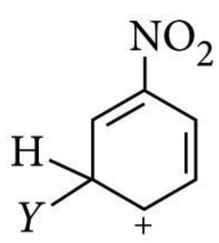
(d)  and 

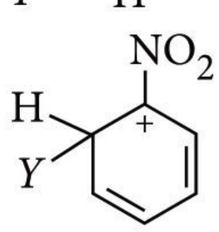
10. Which of the following is a false statement?
(a) Free radicals, carbonium ions and carbanions are reaction intermediates.
(b) Reaction between methane and chlorine in presence of sunlight proceeds *via* free radical.
(c) The electronegative atom in the carbon chain produces +*I* effect.
(d) Homolytic fission of C–C bonds gives free radicals.

11. Which of the following carbocations is expected to be most stable?

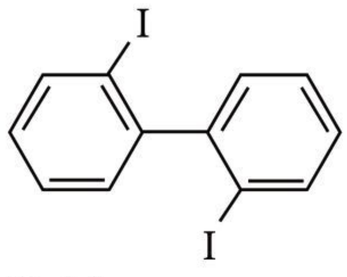
(a) 

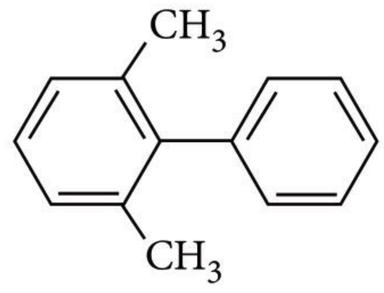
(b) 

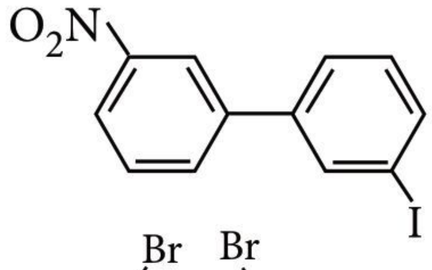
(c) 

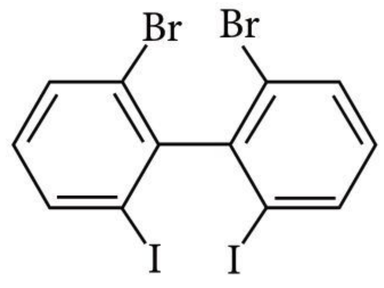
(d) 

12. Which of the following biphenyls is optically active?

(a) 

(b) 

(c) 

(d) 

## Assertion & Reason Type

**Directions :** In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** Alkanes containing more than three carbon atoms exhibit chain isomerism.
**Reason :** In an alkane, all carbon atoms are $sp^3$ hybridised.

14. **Assertion :** The order of reactivity of carbocation is $2° > 3° > 1°$.
**Reason :** Carbon atom in carbonium ion is in $sp^3$ state of hybridisation.

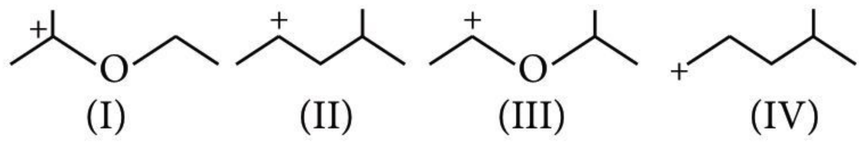
15. **Assertion :** When inductive and electromeric effects operate in opposite directions, the inductive effect predominates.
**Reason :** Inductive effect is the complete transfer of shared pair of π electrons to one of the atoms.

## JEE MAIN / JEE ADVANCED

### Only One Option Correct Type

16. The number of structural and configurational isomers of a bromo compound, $C_5H_9Br$, formed by the addition of HBr to 2-pentyne respectively are
(a) 1 and 2 (b) 2 and 4
(c) 4 and 2 (d) 2 and 1

17. The correct stability order for the following species is


(I) (II) (III) (IV)

(a) (II) > (IV) > (I) > (III)
(b) (I) > (II) > (III) > (IV)
(c) (II) > (I) > (IV) > (III)
(d) (I) > (III) > (II) > (IV)

18. Amongst the following which are true for $S_N2$ reaction?
(i) The rate of reaction is independent of the concentration of the nucleophile.
(ii) The nucleophile attacks the carbon atom on the side of the molecule opposite to the group being displaced.
(iii) The reaction proceeds with simultaneous bond formation and bond rupture.

(a) (i) and (ii) (b) (i) and (iii)
(c) (i), (ii) and (iii) (d) (ii) and (iii)

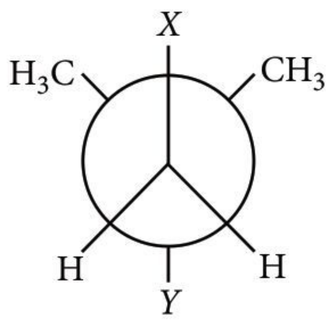
**19.** A dibasic acid containing C, H and O was found to contain C = 26.7% and H = 2.2%. The vapour density of diethyl ester was found to be 73. What is the molecular formula of acid?
(a) $CH_2O_2$ (b) $C_2H_2O_4$
(c) $C_3H_3O_4$ (d) $C_4H_4O_4$

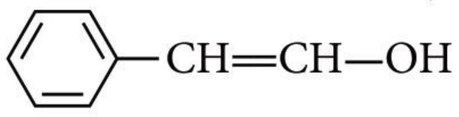
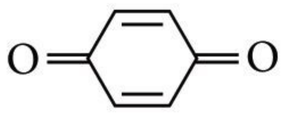
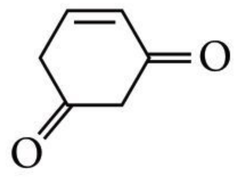
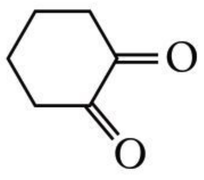
## More than One Option Correct Type

**20.** Which of the following compounds will show geometrical isomerism?
(a) 2-Butene (b) Propene
(c) 1-Phenyl propene (d) 2-Methyl butene

**21.** Which of the following compounds have asymmetric C-atom?
(a) $CH_3-\underset{Br}{\underset{|}{CH}}-CH_2$ (b) $CH_3-\underset{Br}{\underset{|}{CH}}-\underset{CH_3}{\underset{|}{CH}}-CH_3$
(c) $CH_3-CH_2-\underset{Br}{\underset{|}{CH}}-CH_3$
(d) $CH_3-\underset{Br}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-CH_2-CH_3$

**22.** In the Newman projection for 2, 2-dimethylbutane, *X* and *Y* can respectively be
(a) H and H
(b) H and $C_2H_5$
(c) $C_2H_5$ and H
(d) $CH_3$ and $CH_3$




**23.** Tautomerism is exhibited by
(a) 
(b) 
(c) 
(d) 

## Integer / Numerical Value Type

**24.** How many isomers are possible for the compound having molecular formula $C_3H_5Br_3$?

**25.** 0.50 g of an organic compound was Kjeldahlised and the $NH_3$ evolved was absorbed in 50 mL of 0.5 M $H_2SO_4$. The residual acid required 60 $cm^3$ of 0.5 M NaOH. The percentage of nitrogen in the organic compound is _____.

**26.** Out of the following reagents, electrophiles are _____.
(i) $R_3N$ (ii) $:CCl_2$
(iii) $CH_3^+$ (iv) $H_2O$
(v) $H_3O^+$ (vi) $NH_3$

## Comprehension Type

Stability of carbocation, alkyl free radical and alkene can be explained on the basis of hyperconjugation.
In all these cases, there is presence of hydrogen atom at the adjacent carbon atom of $sp^2$ hybridised carbon. Total number of hyperconjugating structures depends upon the number of hydrogen atoms present at adjacent carbon atom of $sp^2$ carbon. More the hyperconjugating structures, more is the stability of the ion.

**27.** Hyperconjugation is not possible in
(a) $CH_3-CH=CH_2$ (b) $CH_2=CH_2$
(c) $CH_3-\overset{+}{C}(CH_3)_2$ (d) $CH_3-\underset{CH_3}{\underset{|}{C}}=\underset{CH_3}{\underset{|}{C}}-CH_3$

**28.** Decreasing order of stability of following alkenes is
(i) $CH_3-CH=CH_2$ (ii) $CH_3-CH=CH-CH_3$
(iii) $CH_3-\underset{CH_3}{\underset{|}{C}}=CH-CH_3$ (iv) $CH_3-\overset{CH_3}{\overset{|}{C}}=\overset{CH_3}{\overset{|}{C}}-CH_3$
(a) (i) > (ii) > (iii) > (iv)
(b) (iv) > (iii) > (ii) > (i)
(c) (iii) > (ii) > (i) > (iv)
(d) (ii) > (iii) > (iv) > (i)

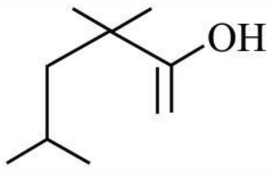
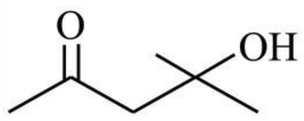
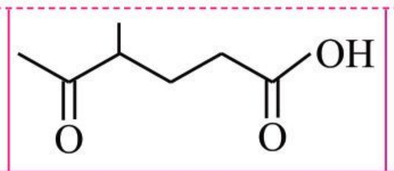
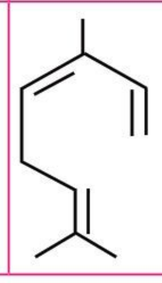
## Matching Type

**29.** Match the reactions in column I with their types given in column II and select the correct option.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Inductive effect | (i) | Delocalisation of σ electrons through the overlapping of *p*-orbital. |
| (B) | Resonance | (ii) | Strong effect |
| (C) | No bond resonance | (iii) | Permanent effect |
| (D) | Electromeric effect | (iv) | Delocalisation of π electrons |

(a) (A) → (i), (B) → (iv), (C) → (iii), (D) → (ii)
(b) (A) → (iv), (B) → (iii), (C) → (i), (D) → (ii)
(c) (A) → (iii), (B) → (iv), (C) → (i), (D) → (ii)
(d) (A) → (i), (B) → (iii), (C) → (iv), (D) → (ii)

**30.** Match the column I (organic compounds) with column II (their IUPAC names) and select the correct option.

| | Column I | | Column II |
|---|---|---|---|
| (A) |  | (i) | 3,7-Dimethylocta-1,3,6-triene |
| (B) |  | (ii) | 4-Methyl-5-oxohexanoic acid |
| (C) |  | (iii) | 3,3,5-Trimethylhex-1-en-2-ol |
| (D) |  | (iv) | 4-Hydroxy-4-methylpentan-2-one |

(a) (A) → (ii), (B) → (i), (C) → (iii), (D) → (iv)
(b) (A) → (iv), (B) → (ii), (C) → (i), (D) → (iii)
(c) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)
(d) (A) → (iii), (B) → (iv), (C) → (ii), (D) → (i)

*Keys are published in this issue. Search now!* ☺

## SELF CHECK

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

**Check your score! If your score is**

| | | |
|---|---|---|
| > 90% | EXCELLENT WORK ! | You are well prepared to take the challenge of final exam. |
| 90-75% | GOOD WORK ! | You can score good in the final exam. |
| 74-60% | SATISFACTORY ! | You need to score more next time. |
| < 60% | NOT SATISFACTORY! | Revise thoroughly and strengthen your concepts. |

## UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

| Column I | Column II |
|---|---|
| 1. LATOCCUIONLF | (a) A heterogeneous system in which one substance is dispersed as very fine particles in another substance called dispersion medium. |
| 2. ALLLBEEAM | (b) Stabilising agent that prevents immiscible liquids from separating. |
| 3. DOOLLIC | (c) The process by which the dispersed particles in a colloid come out of suspension to aggregate into larger clumps. |
| 4. YLPSISROY | (d) Any material that resists the flow of electric current. |
| 5. TORLASUIN | (e) A measure of the concentration of a chemical species, especially of a solute in a solution. |
| 6. LISEMUREIF | (f) Able to be shaped or pounded with a hammer, usually applied to metals. |
| 7. TONRISPO | (g) The antimatter counterpart of an electron, which has a charge of +1. |
| 8. REEUAS | (h) Radioactive transition metal with element symbol Sg. |
| 9. TYLIAROM | (i) The thermal decomposition of materials at elevated temperature in an inert atmosphere such as a vacuum gas. |
| 10. SAOBERMUGI | (j) Nickle-dependent enzyme which catalyses the hydrolysis of urea to ammonia and $CO_2$. |

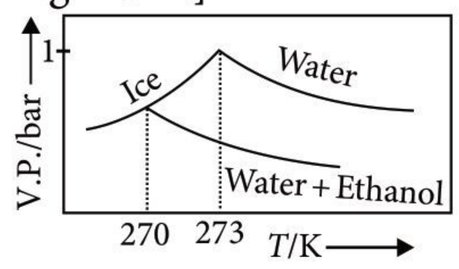
*Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month.*
*Winners' names will be published in next issue.*

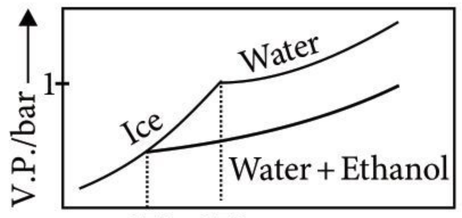
# GET SET GO for JEE

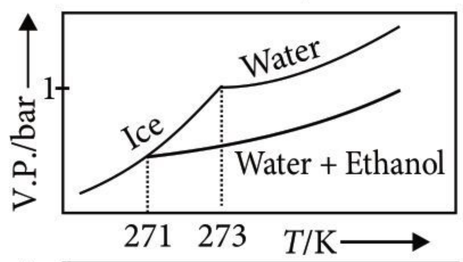

*with exclusive and brain storming MCQs*

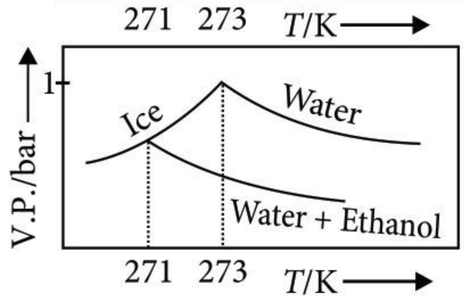
**Practicing these MCQs help to strengthen your concepts and give you extra edge in your JEE preparation**

**1.** Pure water freezes at 273 K and 1 bar. The addition of 34.5 g of ethanol to 500 g of water changes the freezing point of the solution. The figures shown below represent plots of vapour pressure (V.P.) versus temperature ($T$).
Among the following, the option representing change in the freezing point is
[Given : Molecular weight of ethanol is 46 g $mol^{-1}$ and the freezing point depression constant of water is 2 K kg $mol^{-1}$.]

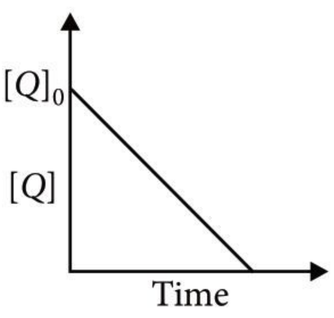
(a)



(b)



(c)



(d)



**2.** In the reaction, $P + Q \rightarrow R + S$, the time taken for 75% reaction of $P$ is twice the time taken for 50% reaction of $P$. The concentration of $Q$ varies with reaction time as shown in the figure. The overall order of the reaction is




(a) 2 (b) 3 (c) 0 (d) 1

**3.** Identify the incorrect statement.
(a) The S – S –S bond angles in the $S_8$ and $S_6$ rings are the same.
(b) Rhombic and monoclinic sulphur have $S_8$ molecules.
(c) $S_2$ is paramagnetic like oxygen.
(d) $S_8$ molecule has a crown shape.

**4.** Match the List I with List II and select the correct option.

| List I | | List II | |
|---|---|---|---|
| (A) | $[Ag(CN)_2]^-$ | (i) | Square planar and 1.73 B.M. |
| (B) | $[Cu(CN)_4]^{3-}$ | (ii) | Linear and 0 B.M. |
| (C) | $[Cu(CN)_6]^{4-}$ | (iii) | Octahedral and 0 B.M. |
| (D) | $[Cu(NH_3)_4]^{2+}$ | (iv) | Tetrahedral and zero |
| (E) | $[Fe(CN)_6]^{4-}$ | (v) | Octahedral and 1.73 B.M. |

(a) A – (ii), B – (iv), C – (v), D – (i), E – (iii)
(b) A – (v), B – (iv), C – (i), D – (iii), E – (ii)

(c) A – (i), B – (iii), C – (iv), D –(ii), E – (v)
(d) A – (iv), B – (v), C – (ii), D – (i), E – (iii)

**5.** Four successive members of the first row transition elements are listed below with atomic numbers. Which one of them is expected to have the highest $E^{\circ}_{M^{3+}/M^{2+}}$ value?

(a) Co ($Z = 27$) (b) Cr ($Z = 24$)
(c) Mn ($Z = 25$) (d) Fe ($Z = 26$)

**6.** Na and Mg crystallize in *bcc* and *fcc* type crystals respectively, then the number of atoms of Na and Mg present in the unit cell of their respective crystal is

(a) 4 and 2 (b) 9 and 14
(c) 14 and 9 (d) 2 and 4

**7.** Identify the set of reagents/reaction conditions '*X*' and '*Y*' in the following set of transformations.

$$CH_3-CH_2-CH_2Br \xrightarrow{X} \text{Product} \xrightarrow{Y} CH_3-\underset{\underset{Br}{|}}{CH}-CH_3$$

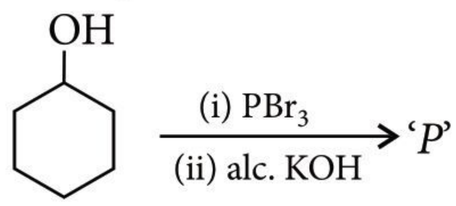
(a) $X$ = Dilute aqueous NaOH, 20°C;
$Y$ = HBr/acetic acid 20°C
(b) $X$ = Concentrated alcoholic NaOH, 80°C;
$Y$ = HBr/acetic acid 20°C
(c) $X$ = Dilute aqueous NaOH, 20°C;
$Y = Br_2/CHCl_3$, 0°C
(d) $X$ = Concentrated alcoholic NaOH, 80°C;
$Y = Br_2/CHCl_3$, 0°C.

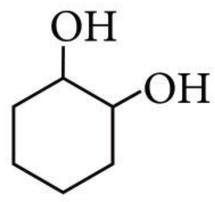
**8.** An aqueous solution of $X$ is added slowly to an aqueous solution of $Y$ as shown in List I. The variation in conductivity of these reactions is given in List II. Match List I with List II and select the correct option.

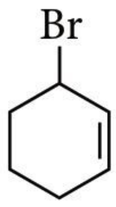
| | List I | | List II |
|---|---|---|---|
| (P) | $(C_2H_5)_3N + CH_3COOH$ ($X$) ($Y$) | (i) | Conductivity decreases and then increases. |
| (Q) | KI (0.1M) + $AgNO_3$ (0.01 M) ($X$) ($Y$) | (ii) | Conductivity decreases and then does not change much. |
| (R) | $CH_3COOH + KOH$ ($X$) ($Y$) | (iii) | Conductivity increases and then does not change much. |
| (S) | NaOH + HI ($X$) ($Y$) | (iv) | Conductivity does not change much and then increases. |

(a) (P) – (iii), (Q) – (iv), (R) – (ii), (S) – (i)
(b) (P) – (iv), (Q) – (iii), (R) – (ii), (S) – (i)
(c) (P) – (ii), (Q) – (iii), (R) – (iv), (S) – (i)
(d) (P) – (i), (Q) – (iv), (R) – (iii), (S) – (ii)

**9.** Predict the final product '*P*'.




(a) 
(b) 

(c) 

(d) 

**10.** In Cannizzaro reaction given below:

$$2PhCHO \xrightarrow{OH^-} PhCH_2OH + PhCOO^-$$

the slowest step is

(a) the attack of $OH^-$ at the carboxyl group
(b) the transfer of hydride to the carbonyl group
(c) the abstraction of proton from the carboxylic group
(d) the deprotonation of $PhCH_2OH$.

**11.** The action of nitrous acid on an aliphatic primary amine gives

(a) secondary amine (b) nitroalkane
(c) alcohol (d) alkyl nitrite.

**12.** Polydispersity index (PDI) is

(a) $\frac{\bar{M}_w}{\bar{M}_n}$ (b) $\frac{\bar{M}_n}{\bar{M}_w}$
(c) $\bar{M}_n \times \bar{M}_w$ (d) $\bar{M}_w - \bar{M}_n$

## NUMERICAL PROBLEMS

**13.** Among the following, how many compounds show the behaviour of neutral flux?
KF, $Fe_2O_3$, $Na_3AlF_6$, $MgSiO_3$, $CaF_2$, NaF, $Mn_3O_4$

**14.** The number of chiral carbon(s) present in peptide, Ile-Arg-Pro, is _____.

**15.** The number of $sp^2$-hybridised carbons present in "Aspartame" is _____.

## SOLUTIONS

**1.** **(b):** Depression in freezing point, $\Delta T_f = K_f \cdot m$
where, $K_f$ = Freezing point depression constant,
$m$ = Molality

$$m = \frac{\text{No. of moles of solute}}{\text{Mass of solvent (in kg)}} = \frac{\frac{34.5}{46}}{\frac{500}{1000}} = 1.5 \text{ mol kg}^{-1}$$

$\therefore \quad \Delta T_f = 2 \times 1.5 = 3$ K

$\Delta T_f = T_f^\circ - T_f$

$3 = 273 - T_f$ (Freezing point of $H_2O$ = 273 K)

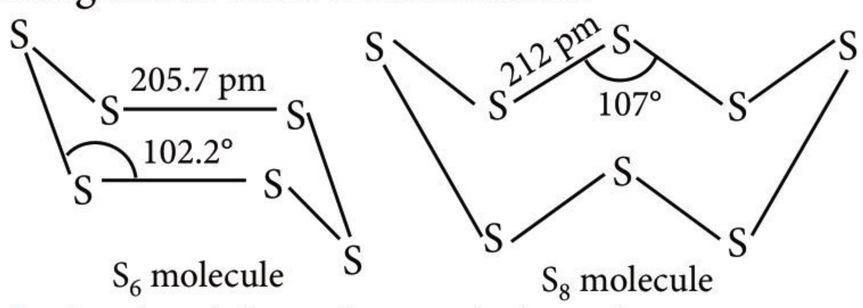
$T_f = 273 - 3 = 270$ K

Thus, freezing point of solution = 270 K

Also, as temperature increases, the vapour pressure increases. Hence, the correct curve is given in option (b).

**2.** **(d) :** For $P$, if $t_{50\%} = x$, then $t_{75\%} = 2x$. So, order with respect to $P$ is 1. From the given graph, concentration of $Q$ decreases linearly with time. So, rate with respect to $Q$, remains constant. Hence, order of reaction with respect to $Q$ is zero.
The rate law expression; $r = k[P]^1[Q]^0$
So, overall order is 1 + 0 = 1.

**3.** **(a) :** Sulphur has puckered $S_8$ rings with crown conformation and Engel's sulphur contains $S_6$ rings arranged in a chair conformation.




$S_6$ molecule $\qquad$ $S_8$ molecule

**4.** **(a) :** $[Ag(CN)_2]^-$ is linear ($sp$) with no unpaired electron hence, magnetic moment = 0

$[Cu(CN)_4]^{3-}$ is tetrahedral ($sp^3$) with no unpaired electron hence, magnetic moment = 0

$[Cu(CN)_6]^{4-}$ is octahedral ($sp^3d^2$) with one unpaired electron hence, magnetic moment $= \sqrt{1(1+2)} = 1.73$ B.M.

$[Cu(NH_3)_4]^{2+}$ is square planar ($dsp^2$) with one unpaired electron hence, magnetic moment $= \sqrt{1(1+2)} = 1.73$ B.M.

$[Fe(CN)_6]^{4-}$ is octahedral ($d^2sp^3$) with no unpaired electron hence, magnetic moment = 0.

**5.** (a) **6.** (d)

**7.** **(b) :**

$$CH_3 - CH_2 - CH_2Br \xrightarrow[80^\circ C, -HBr]{NaOH\ (alc.)} CH_3 - CH{=}CH_2 \xrightarrow{HBr} CH_3 - \underset{\displaystyle Br}{\underset{|}{CH}} - CH_3$$

**8.** **(a) :**

$$P : \underset{(X)}{(C_2H_5)_3N} + \underset{(Y)}{CH_3COOH} \longrightarrow CH_3COO^- + (C_2H_5)_3NH^+$$

Initially, conductivity increases due to ion formation after that, it becomes practically constant because $X$ alone cannot form ions.

$$Q : \underset{(X)}{KI(0.1\text{ M})} + \underset{(Y)}{AgNO_3(0.01\text{ M})} \longrightarrow AgI\downarrow + KNO_3$$

Number of ions in the solution remains constant until all the $AgNO_3$ is precipitated out as AgI. Thereafter, conductance increases due to increase in number of ions.

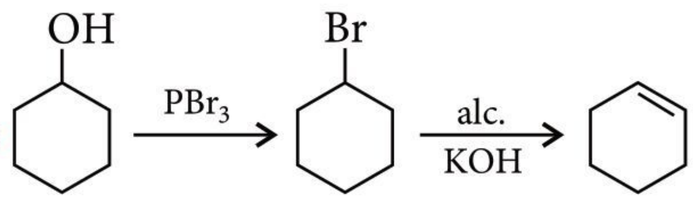
$$R : \underset{(X)}{CH_3COOH} + \underset{(Y)}{KOH} \longrightarrow CH_3COOK + H_2O$$

Initially, conductance decreases due to the decrease in the number of $OH^-$ ions. Thereafter, it slowly increases (not much) due to increase in number of $H^+$ ions as $CH_3COOH$ is a weak acid.

$$S : \underset{(X)}{NaOH} + \underset{(Y)}{HI} \longrightarrow NaI + H_2O$$

Initially, conductivity decreases due to the decrease in $H^+$ ions and then, increases due to the increase in $OH^-$ ions.

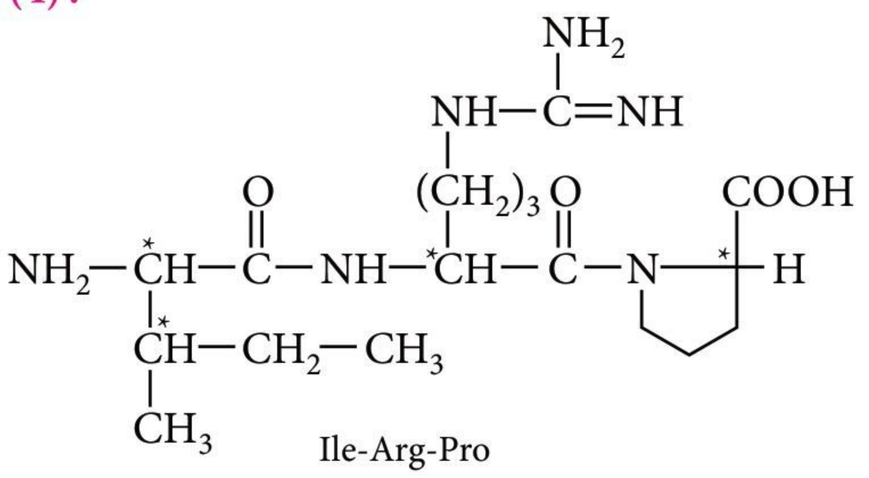
**9.** **(a) :**



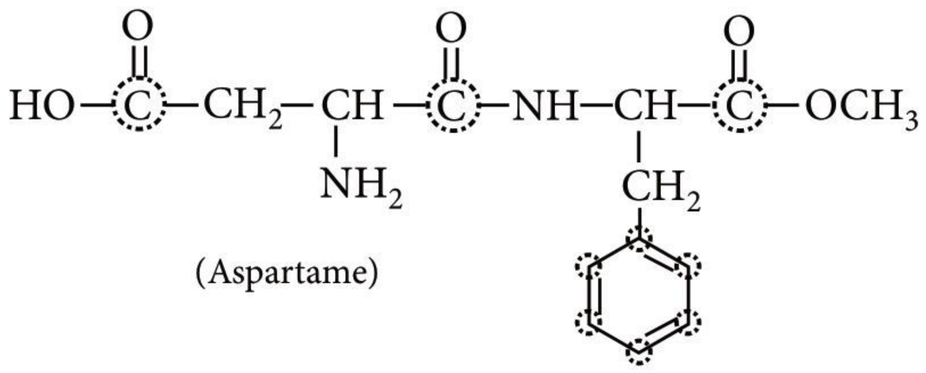

**10.** (b) **11.** (c) **12.** (a)

**13.** **(3) :** The neutral compound added to decrease the melting point and to make the ore conducting in an electrolytic cell is called neutral flux, *i.e.*, $CaF_2$, $Na_3AlF_6$, KF.

**14.** **(4) :**




**15.** **(9) :**




Total number of $sp^2$ hybridised carbon atoms is 9.

BRUSH UP

for

# NEET/JEE

CLASS-XII

**Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.**

## Unit 4 The *p*-Block Elements | The *d*- and *f*-Block Elements

### The *p*-Block Elements

## Group 15 Elements (Nitrogen Family)

### Electronic Configuration

| Element | At. No. | Electronic Configuration | Oxidation State |
|---|---|---|---|
| Nitrogen (N) | 7 | [He] $2s^2 2p^3$ | −3, −2, −1, 0, +1, +2, +3, +4, +5 |
| Phosphorus (P) | 15 | [Ne] $3s^2 3p^3$ | −3, +3, +5 |
| Arsenic (As) | 33 | [Ar] $3d^{10} 4s^2 4p^3$ | −3, +3, +5 |
| Antimony (Sb) | 51 | [Kr] $4d^{10} 5s^2 5p^3$ | −3, +3, +5 |
| Bismuth (Bi) | 83 | [Xe] $4f^{14} 5d^{10} 6s^2 6p^3$ | +3, +5 |
| Moscovium (Mc) | 115 | [Rn] $5f^{14} 6d^{10} 7s^2 7p^3$ | – |

### Physical Properties

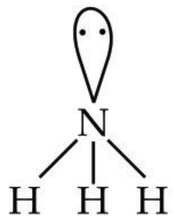
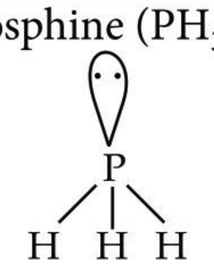
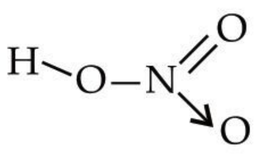
- **Atomic radii and ionic radii** increase down the group and are smaller than that of group 14 elements due to increased nuclear charge.
- **Melting point** first increases from N to As due to increase in their atomic size and then decreases to Bi because of their tendency to form three covalent bonds instead of five due to inert pair effect.
- **Ionisation enthalpy** decreases regularly down the group due to increase in size and is much greater than group 14 elements due to extra stability of half filled *p*-orbitals.
- **Electronegativity** decreases down the group.
- **Allotropy :** All elements except Bi show allotropy. Phosphorus has three allotropes *i.e.*, white, red and black phosphorus. Arsenic and antimony exist in two allotropic forms *i.e.*, yellow and grey.

### General Trends

- **Hydrides :**
  - **Bond angle, Thermal stability and Basic strength:** $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$
  - **B.Pt. :** $PH_3 < AsH_3 < NH_3 < SbH_3 < BiH_3$
  - **M.Pt. :** $PH_3 < AsH_3 < SbH_3 < NH_3$
  - **Reducing nature :** $NH_3 < PH_3 < AsH_3 < SbH_3 < BiH_3$
- **Halides :**
  - **Bond angle :** $PF_3 < PCl_3 < PBr_3 < PI_3$
  - **Lewis acid strength :** $PCl_3 > AsCl_3 > SbCl_3$; $PF_3 > PCl_3 > PBr_3 > PI_3$

## Important Compounds of Nitrogen Family

| Structure | Preparation | Properties | Uses |
|---|---|---|---|
| Nitrogen ($N_2$) <br> $N \equiv N$ | $NH_4Cl_{(aq)} + NaNO_{2(aq)} \rightarrow N_{2(g)} + 2H_2O_{(l)} + NaCl_{(aq)}$ | $N_2 \xrightarrow{6Li} 2Li_3N$; $N_2 \xrightarrow{3Mg} Mg_3N$; $N_2 \xrightarrow{3H_2} 2NH_3$; $N_2 \xrightarrow{O_2} 2NO$ | In manufacturing of ammonia, used where inert atmospheres are required, in refrigerant, preservatives. |

| | | |
|---|---|---|
| Ammonia ($NH_3$)<br>  | $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$;<br>$\Delta H_f^\circ = -46.1$ kJ/mol<br>(Haber's process) | $NH_3 \xrightarrow{O_2} N_2 + H_2O$<br>$NH_3 \xrightarrow{Cl_2} NH_4Cl + N_2$<br>$NH_3 \xrightarrow[\text{If } NH_3 \text{ (excess)}]{Cl_2} NCl_3 + HCl$<br>$NH_3 \xrightarrow[\text{If } Cl_2 \text{ (excess)}]{O_2, Pt} NO + H_2O$<br>$NH_3 \xrightarrow{AgCl} [Ag(NH_3)_2]Cl$ | In refrigerators, manufacturing of rayon, $HNO_3$ (Ostwald's process), $NaHCO_3$ (Solvay's process), nitrogenous fertilizers. |
| Phosphine ($PH_3$)<br>  | $Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3\uparrow$ | $PH_3 \xrightarrow{CuSO_4} Cu_3P_2 + H_2SO_4$<br>$PH_3 \xrightarrow{HCl} PH_4^+Cl^-$<br>$PH_3 \xrightarrow{O_2} H_3PO_4$<br>$PH_3 \xrightarrow{N_2O} N_2 + H_3PO_4$ | For production of smoke screens. Phosphine in combination with acetylene is used in Holme's signals. |
| Nitric acid ($HNO_3$)<br>  | $NaNO_3 + H_2SO_4 \xrightarrow{\Delta} NaHSO_4 + HNO_3$ | $HNO_3 \xrightarrow{SO_2} H_2SO_4 + NO_2$<br>$HNO_3 \xrightarrow{Sn} H_2SnO_3 + NO_2 + H_2O$<br>$HNO_3 \xrightarrow{HCl} H_2O + NOCl + [Cl]$ | As fertilizers, explosives, perfumes, dyes and medicines. As oxidiser in rocket fuels. |

## Oxides of Nitrogen

- **Preparation and properties of oxides of nitrogen :**

| Name | Formula | O.S. | Preparation | Physical appearance and chemical nature |
|---|---|---|---|---|
| Dinitrogen oxide | $N_2O$ | +1 | $NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$ | colourless gas, neutral |
| Nitrogen monoxide | NO | +2 | $2NaNO_2 + 2FeSO_4 + 3H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + 2NaHSO_4 + 2H_2O + 2NO$ | colourless gas, neutral |
| Dinitrogen trioxide | $N_2O_3$ | +3 | $2NO + N_2O_4 \xrightarrow{250\ K} 2N_2O_3$ | blue solid, acidic |
| Nitrogen dioxide | $NO_2$ | +4 | $2Pb(NO_3)_2 \xrightarrow{673\ K} 2PbO + 4NO_2 + O_2$ | brown gas, acidic |
| Dinitrogen tetraoxide | $N_2O_4$ | +4 | $2NO_2 \underset{\text{Heat}}{\overset{\text{Cool}}{\rightleftharpoons}} N_2O_4$ | colourless solid/ liquid, acidic |
| Dinitrogen pentaoxide | $N_2O_5$ | +5 | $4HNO_3 + P_4O_{10} \longrightarrow 4HPO_3 + 2N_2O_5$ | colourless solid, acidic |

## Phosphorus-Allotropic Forms

- **White phosphorus :** It is a white translucent waxy solid and consists of discrete tetrahedral $P_4$ molecule.
  - It dissolves in boiling NaOH solution in an inert atmosphere giving $PH_3$ and readily catches fire.
- **Red phosphorus :** It is obtained by heating white phosphorus at 573 K in an inert atmosphere for several days. It possesses iron grey lustre.
- **Black phosphorus :** It has two forms :
  - α-black phosphorus is formed when red phosphorus is heated in a sealed tube at 803 K.
  - β-black phosphorus is prepared by heating white phosphorus at 473 K under high pressure.

## Phosphine

- **Preparation :**

$Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$

$Ca_3P_2 + 6HCl \longrightarrow 3CaCl_2 + 2PH_3$

- **Properties :** It is a colourless gas with rotten fish smell and is highly poisonous.

$4PH_3 \xrightarrow{\Delta} \underset{\text{Red phosphorus}}{P_4} + 6H_2$

$3CuSO_4 + 2PH_3 \longrightarrow \underset{\text{Copper phosphide}}{Cu_3P_2} + 3H_2SO_4$

$PH_3 + HBr \longrightarrow \underset{\text{Phosphonium bromide}}{PH_4Br}$

## Phosphorus Halides

| Compound | Preparation | Properties | Uses |
|---|---|---|---|
| $PCl_5$ (Trigonal bipyramidal) | $P_4 + 10Cl_2 \rightarrow 4PCl_5$ (white or red) | $PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$ (excess)<br>$PCl_5 + SO_2 \rightarrow SOCl_2 + POCl_3$ | used as chlorinating and dehydrating agent. |
| $PCl_3$ (Pyramidal) | $P_4 + 6Cl_2 \rightarrow 4PCl_3$ | $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$<br>$3CH_3COOH + PCl_3 \rightarrow 3CH_3COCl + H_3PO_3$ | used as reagent in organic synthesis and as a precursor. |

## Oxoacids of Phosphorus

| Name | Formula | Oxidation state of phosphorus | Preparation |
|---|---|---|---|
| Hypophosphorous acid (Phosphinic acid) | $H_3PO_2$ | +1 | White $P_4$ + alkali |
| Orthophosphorous acid (Phosphonic acid) | $H_3PO_3$ | +3 | $P_2O_3 + H_2O$ |
| Pyrophosphorous acid | $H_4P_2O_5$ | +3 | $PCl_3 + H_3PO_3$ |
| Hypophosphoric acid | $H_4P_2O_6$ | +4 | Red $P_4$ + alkali |
| Orthophosphoric acid | $H_3PO_4$ | +5 | $P_4O_{10} + H_2O$ |
| Pyrophosphoric acid | $H_4P_2O_7$ | +5 | Phosphoric acid + heat |
| Metaphosphoric acid | $(HPO_3)_n$ | +5 | Phosphorus acid + $Br_2$, heated in a sealed tube |

# Group 16 Elements (Oxygen Family)

## Electronic Configuration

| Element | At. No. | Electronic Configuration | Oxidation State |
|---|---|---|---|
| Oxygen (O) | 8 | [He] $2s^2 2p^4$ | –2, –1, +1, +2 |
| Sulphur (S) | 16 | [Ne] $3s^2 3p^4$ | –2, +2, +4, +6 |
| Selenium (Se) | 34 | [Ar] $3d^{10} 4s^2 4p^4$ | –2, +2, +4, +6 |
| Tellurium (Te) | 52 | [Kr] $4d^{10} 5s^2 5p^4$ | –2, +2, +4, +6 |
| Polonium (Po) | 84 | [Xe] $4f^{14} 5d^{10} 6s^2 6p^4$ | +2, +4, +6 |
| Livermorium (Lv) | 116 | [Rn] $5f^{14} 6d^{10} 7s^2 7p^4$ | – |

## Physical Properties

- **Atomic and ionic radii** increase down the group.
- **Ionisation enthalpy** decreases down the group and is less than that of group 15 elements due to stability of half filled *p*-subshell of group 15 elements.
- **Electronegativity** decreases down the group.
- **Electron gain enthalpy** for oxygen is less negative than sulphur due to its small size. However, from sulphur onwards it again becomes less negative upto polonium.
- **Melting and boiling points** increase down the group with increase in atomic size upto Te while Po has both m.pt. and b.pt. less than Te.
- **Elemental state :** Oxygen is diatomic ($O_2$) due to $p\pi - p\pi$ multiple bonding. S, Se and Te exist as octa atomic ($S_8$, $Se_8$, $Te_8$) due to absence of $p\pi - p\pi$ multiple bonding.
- All the elements of group 16 exhibit **allotropy.**

## General Trends

- **Hydrides :**
  - **Bond angle and Thermal stability :** $H_2O > H_2S > H_2Se > H_2Te$
  - **Volatility :** $H_2S > H_2Se > H_2Te > H_2O$
  - **Acidic strength and Reducing nature :** $H_2O < H_2S < H_2Se < H_2Te$
- **Halides :**
  - **Stability :** $SF_6 > SeF_6 > TeF_6$

## Anomalous Behaviour of Oxygen

- Oxygen differs from the rest of the elements of oxygen family due to
  - small size
  - high electronegativity
  - non-availability of *d*-orbitals.
- **Points of difference :**
  - Oxygen is a diatomic gas while others are solids.
  - Oxygen exhibits oxidation states of –2, –1 and +2 only while other members show both negative and positive oxidation states like –2, +2, +4 and +6.
  - Due to high electronegativity of oxygen, hydrogen bonding is present in water.
  - Oxygen is highly non-metallic due to high electronegativity.
  - Oxygen is paramagnetic while others are diamagnetic.

### Dioxygen

- **Preparation :** $2HgO \xrightarrow{\Delta} 2Hg + O_2$
- **Physical properties :** Colourless, odourless, tasteless, sparingly soluble in water.
- **Chemical properties :** $C + O_2 \rightarrow CO_2$;
  $Pb + O_2 \rightarrow PbO_2$
- **Uses :** In welding and cutting, as fuel in rocket.

### Ozone

- **Preparation :** $3O_2 \rightleftharpoons 2O_3$
- **Physical properties :** Pale blue gas or dark blue liquid or violet black solid, strong characteristic smell.
- **Chemical properties :**

$O_3$ →
- NO → $O_2 + NO_2$
- $H_2S$ → $H_2O + S + O_2$
- PbS → $PbSO_4$
- KOH → $KO_3$
- $CH_2 = CH_2$ → HCHO
- $HCl + SnCl_2$ → $SnCl_4$

### Simple oxide

- A binary compound of oxygen with other elements is oxide. It can be classified into acidic, basic, neutral, amphoteric and mixed on the basis of their reactivity.

### Allotropes of Sulphur

Two allotropes of sulphur are known; yellow rhombic and monoclinic.

### Sulphur Dioxide

- **Preparation :** $S + O_2 \rightarrow SO_2$
  $4FeS_2 + 110_2 \rightarrow 2Fe_2O_3 + 8SO_2$
- **Physical properties :** Colourless gas with pungent smell.
- **Chemical properties :**
  $SO_2 + H_2O \rightleftharpoons H_2SO_3$ (reaction with water)
  $2NaOH + SO_2 \rightarrow Na_2SO_3 + H_2O \xrightarrow{SO_2} 2NaHSO_3$
- **Uses :** It is angular, used in refining petroleum and in bleaching wool.

### Sulphuric Acid (Oil of Vitrol)

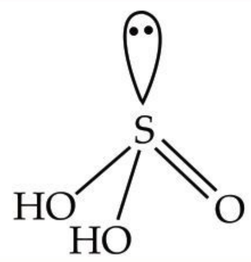
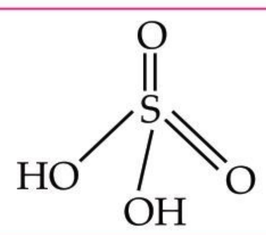
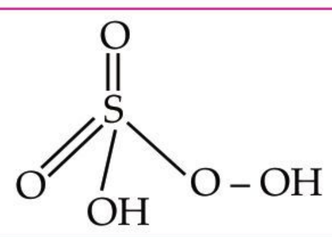
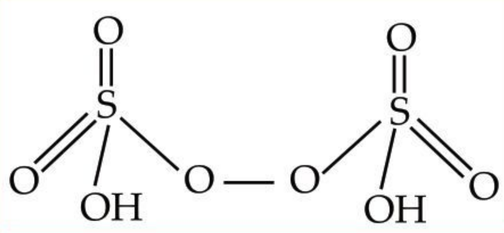
**Preparation :**

$H_2O + SO_3 \rightarrow H_2SO_4$ ; $H_2O_2 + SO_2 \rightarrow H_2SO_4$

**Chemical properties :**

$H_2SO_4$ →
- NaOH → $NaHSO_4 + H_2O$
- 2NaOH → $Na_2SO_4 + 2H_2O$
- Zn → $ZnSO_4 + H_2$
- $C_{12}H_{22}O_{11}$ → $12C + 11H_2O$
- $S_8$ → $SO_2 + H_2O$
- $Na_2S$ → $Na_2SO_4 + H_2S$
- $BaCl_2$ → $BaSO_4 + HCl$
- $K_4[Fe(CN)_6]$ → $K_2SO_4 + FeSO_4 + (NH_4)_2SO_4 + CO\uparrow$

## Some Important Oxoacids of Sulphur

| Oxoacid | Oxidation state, basicity and salt type | Structure | Properties |
|---|---|---|---|
| Sulphurous acid, $H_2SO_3$ | S = +4, dibasic, and forms two series of salts : sulphites ($SO_3^{2-}$) and bisulphites ($HSO_3^-$) |  | – Acts as reducing agent as well as oxidising agent.<br>– Exists only in solution. |
| Sulphuric acid, $H_2SO_4$ | S = +6, dibasic and forms two series of salts : sulphates ($SO_4^{2-}$) and bisulphates ($HSO_4^-$) |  | – Highly corrosive<br>– Acts as oxidising agent and dehydrating agent. |
| Peroxomonosulphuric acid (Caro's acid), $H_2SO_5$ | S = +6, monobasic and forms single type of salt : peroxymonosulphates ($HSO_5^-$) |  | – White, crystalline and hygroscopic solid.<br>– Powerful oxidising agent. |
| Peroxodisulphuric acid (Marshall's acid), $H_2S_2O_8$ | S = +6 and forms single type of salt : peroxydisulphates ($S_2O_8^{2-}$) |  | – Colourless, crystalline and hygroscopic solid.<br>– Strong oxidising agent. |

## Group 17 Elements (Halogens Family)

### Electronic Configuration

| Element | At. No. | Electronic Configuration | Oxidation State |
|---|---|---|---|
| Fluorine (F) | 9 | $[He]2s^2 2p^5$ | –1 |
| Chlorine (Cl) | 17 | $[Ne]3s^2 3p^5$ | –1, +1, +3, +5, +7 |
| Bromine (Br) | 35 | $[Ar]3d^{10} 4s^2 4p^5$ | –1, +1, +3, +5, +7 |
| Iodine (I) | 53 | $[Kr]4d^{10} 5s^2 5p^5$ | –1, +1, +3, +5, +7 |
| Astatine (At) | 85 | $[Xe]4f^{14} 5d^{10} 6s^2 6p^5$ | – |
| Tennessine (Ts) | 117 | $[Rn]5f^{14} 6d^{10} 7s^2 7p^5$ | – |

### Physical Properties

- **Atomic and ionic radii** increase down the group and halogens are smallest atoms in a period.
- **Ionisation enthalpy** is very high and decreases down the group.
- **Electronegativity** decreases down the group and fluorine is the most electronegative element.
- **Electron gain enthalpy** increases from F to Cl and then decreases till I. Smaller electron gain enthalpy of F is due to small size and interelectronic repulsions.
- **Bond dissociation enthalpy** increases from $F_2$ to $Cl_2$ and then decreases in $Br_2$ and $I_2$. F—F bond is weaker than Cl—Cl bond because of the large repulsions of the lone pairs of $F_2$ which are closer than in $Cl_2$.
- **Melting points and boiling points** increase down the group.

### General Trends

- **Oxidising power :** $F_2 > Cl_2 > Br_2 > I_2$
- **Hydrogen halides :**
  - **B.Pt. and M.Pt. :** HF > HI > HBr > HCl
  - **Dipole moment and Thermal stability :** HF > HCl > HBr > HI
  - **Bond length, Acidic strength and Reducing nature:** HF < HCl < HBr < HI

### Oxoacids of Halogens

- **Acidic strength :** $HClO < HClO_2 < HClO_3 < HClO_4$
  $HOCl > HOBr > HOI$
  $HClO_4 > HBrO_4 > HIO_4$
- **Oxidising power :** $HClO > HClO_2 > HClO_3 > HClO_4$

### Oxides

- Fluorine forms two oxides $OF_2$ and $O_2F_2$ called oxygen fluorides, other halogens form oxides in

which oxidation states of these halogens range from +1 to +7.

- The higher oxides of halogens are more stable than the lower ones.

### Metal Halides

- **Ionic character :** $MF > MCl > MBr > MI$
- For metals exhibiting more than one oxidation states, the halides in higher oxidation states will be more covalent than the one in lower oxidation states.

### Chlorine

**Preparation :**

$4HCl + O_2 \xrightarrow{CuCl_2} 2Cl_2 + 2H_2O$ [Deacon's process]

It is also prepared by electrolysis of water.

**Physical properties :** Greenish yellow gas and pungent odour.

**Chemical properties :**

$Cl_2 \xrightarrow{2Al} 2AlCl_3$

$Cl_2 \xrightarrow{2Na} 2NaCl$ ; $Cl_2 \xrightarrow{H_2} 2HCl$

$Cl_2 \xrightarrow{H_2S} 2HCl + S$

$Cl_2 \xrightarrow{2Fe} 2FeCl_3$

$Cl_2 \xrightarrow{8NH_3} 6NH_4Cl + N_2$

$Cl_2 \xrightarrow{2NaOH} NaCl + NaOCl + H_2O$

$Cl_2 \xrightarrow{6NaOH} 5NaCl + NaClO_3 + 2H_2O$

### Hydrogen Chloride

**Preparation :** $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$

**Physical properties :** Colourless and pungent smelling gas.

**Chemical properties :**

$HCl \xrightarrow{NH_3} NH_4Cl$

$HCl \xrightarrow{Na_2CO_3} 2NaCl + H_2O + CO_2$

$HCl \xrightarrow{NaHCO_3} NaCl + H_2O + CO_2$

$HCl \xrightarrow{Na_2SO_3} NaCl + H_2O + SO_2$

### Oxoacids of Halogens

Hypochlorous acid, chlorous acid, choloric acid and perchloric acid are some oxoacids of halogens.

## Interhalogen Compounds

| Type | Hybridisation | Shape | Geometry |
|---|---|---|---|
| $XX'$ | $sp^3$ | Linear | Tetrahedral |
| $XX'_3$ | $sp^3d$ | T-shaped | Trigonal bipyramidal |
| $XX'_5$ | $sp^3d^2$ | Square bipyramidal | Octahedral |
| $XX'_7$ | $sp^3d^3$ | Pentagonal bipyramidal | Pentagonal bipyramidal |

## Group 18 Elements (Noble Gases)

### Electronic Configuration

| Element | Atomic no. | Electronic configuration |
|---|---|---|
| Helium (He) | 2 | $1s^2$ |
| Neon (Ne) | 10 | [He] $2s^2\ 2p^6$ |
| Argon (Ar) | 18 | [Ne] $3s^2\ 3p^6$ |
| Krypton (Kr) | 36 | [Ar] $3d^{10}\ 4s^2\ 4p^6$ |
| Xenon (Xe) | 54 | [Kr] $4d^{10}\ 5s^2\ 5p^6$ |
| Radon (Rn) | 86 | [Xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^6$ |
| Oganesson (Og) | 118 | [Rn] $5f^{14}\ 6d^{10}\ 7s^2\ 7p^6$ |

### Physical Properties

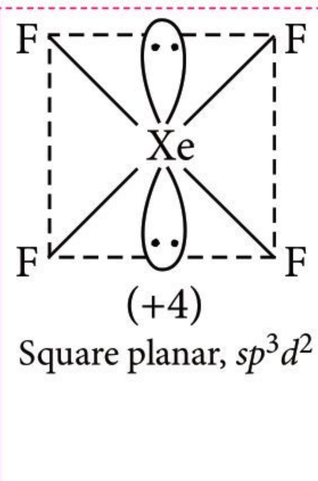
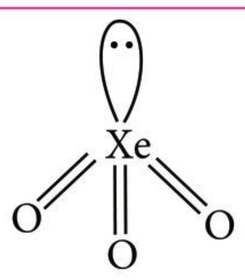
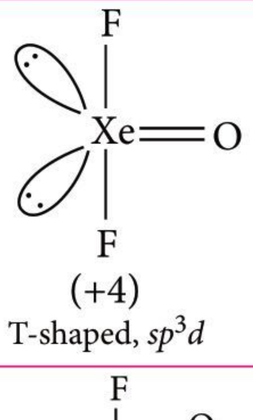
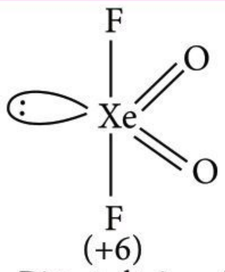
- **Ionisation enthalpy** is very high and decreases down the group with increase in size.
- **Atomic radii** increase down the group.
- **Electron gain enthalpy** is positive as noble gases have no tendency to accept the electrons.
- **Melting points and boiling points** are very low due to weak interatomic dispersion forces.

### General Trends

- **M.Pt., B.Pt., Ease of liquefaction, Solubility, Adsorption and Polarisability :**
  $He < Ne < Ar < Kr < Xe$
- **Thermal conductivity :** $He > Ne > Ar > Kr > Xe$

### Compounds of Xenon

| Compound | Structure | Preparation | Properties |
|---|---|---|---|
| $XeF_2$ (Xenon difluoride) | F, Xe, F (+2) Linear, $sp^3d$ | $Xe + F_2 \xrightarrow[400°C]{\text{Ni tube}} XeF_2$ (2 : 1)<br>$Xe + O_2F_2 \xrightarrow{-178°C} XeF_2 + O_2$ | $XeF_2 \xrightarrow{H_2} Xe + 2HF$<br>$XeF_2 \xrightarrow{H_2O} Xe + 2HF + \frac{1}{2}O_2$<br>$XeF_2 \xrightarrow[BF_3]{I_2} 2IF + Xe$<br>$XeF_2 \xrightarrow{2HCl} Xe + 2HF + Cl_2$<br>– acts as fluorinating agent. |

| | | | |
|---|---|---|---|
| $XeF_4$ (Xenon tetrafluoride) |   (+4) Square planar, $sp^3d^2$ | $Xe + F_2 \xrightarrow[600°C]{\text{Ni tube}} XeF_4$ (1 : 5) | – Colourless, crystalline solid with melting point, 117.1°C.<br>– $XeF_4 + 2H_2 \longrightarrow Xe + 4HF$<br>– undergoes disproportionation in water.<br>$6XeF_4 + 12H_2O \longrightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$<br>– $XeF_4 + SbF_5 \longrightarrow [XeF_3]^+ [SbF_6]^-$<br>– acts as fluorinating agent. |
| $XeO_3$ (Xenon trioxide) |   (+6) Pyramidal, $sp^3$ | Complete hydrolysis of $XeF_4$ and $XeF_6$ :<br>$6XeF_4 + 12H_2O \longrightarrow 4Xe + 2XeO_3 + 3O_2 + 24HF$<br>$XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HF$ | – colourless, highly explosive and powerful oxidising agent.<br>– undergoes disproportionation when dissolved in alkali.<br>$2XeO_3 + 4OH^- \longrightarrow Xe + O_2 + XeO_6^{4-} + 2H_2O$ |
| $XeOF_2$ (Xenon oxydifluoride) |   (+4) T-shaped, $sp^3d$ | Partial hydrolysis of $XeF_4$ :<br>$XeF_4 + H_2O \longrightarrow XeOF_2 + 2HF$ | – unstable |
| $XeO_2F_2$ (Xenon dioxydifluoride) |   (+6) Distorted trigonal bipyramidal, $sp^3d$ | Partial hydrolysis of $XeOF_4$ or $XeF_6$ :<br>$XeOF_4 + H_2O \longrightarrow XeO_2F_2 + 2HF$<br>$XeF_6 + 2H_2O \longrightarrow XeO_2F_2 + 4HF$<br>Action of $SiO_2$ on $XeOF_4$ :<br>$2XeOF_4 + SiO_2 \longrightarrow 2XeO_2F_2 + SiF_4$ | – colourless solid.<br>– undergoes hydrolysis readily.<br>$XeO_2F_2 + H_2O \longrightarrow XeO_3 + 2HF$ |

- $XeF_6$ cannot be stored in glass vessels because with glass, it form explosive $XeO_3$
  $2XeF_6 + SiO_2 \longrightarrow 2XeOF_4 + SiF_4$ ;
  $2XeOF_4 + SiO_2 \longrightarrow 2XeO_2F_2 + SiF_4$ ;
  $2XeO_2F_2 + SiO_2 \longrightarrow 2XeO_3 + SiF_4$
  (from glass) (explosive)

## Uses of Noble Gases

- Helium is used as breathing mixture (or oxygen dilutant) for divers.
- Mixture of $O_2$ and He is used in the treatment of asthma.
- Neon lighting is used for advertising.
- Argon is primarily used to create an inert atmosphere in light bulbs, welding and fluorescent bulbs.
- The light emitted by krypton in an electric discharge tube is used for runway and approach lights in airports.
- Xenon is used in electrical flash bulbs for high speed photography.
- Radon is used in radiotherapy of cancer.

# The *d*- and *f*- Block Elements

## Transition Elements (*d*-Block Elements)

- Transition elements are the elements which lie in between *s*- and *p*-block elements in the long form of periodic table.
  – They are called *d*-block elements as the last electron enters in the *d*-orbital.
  – General electronic configuration : $(n-1)d^{1-10}ns^{1-2}$
- **Transition series :** *d*-block consists of four transition series,
  1st Transition series or 3*d* series : $_{21}Sc - _{30}Zn$
  2nd Transition series or 4*d* series : $_{39}Y - _{48}Cd$
  3rd Transition series or 5*d* series : $_{57}La, _{72}Hf - _{80}Hg$
  4th Transition series or 6*d* series : $_{89}Ac, _{104}Rf - _{112}Cn$

## General Characteristics

**Metallic character :** Due to low, ionisation potentials and presence of vacant *d*-orbitals, they are metallic.

**Chemical reactivity :** Due to high ionisation energy, high sublimation energy and low heat of hydration, they are not reactive.

**Ionisation energy :** Only small variation in ionisation potentials due to the simultaneous increase in nuclear charge as well as screening effect.

**Magnetic properties :** The magnetic moment increases with the increasing number of unpaired electrons.

**Complex formation :** Due to presence of vacant *d*-orbitals, small size and high charge density, they form large complexes.

**Catalytic properties :** Due to presence of vacant *d*-orbitals and variable oxidation states, they are catalytic in nature.

**High melting and boiling points :** Due to formation of covalent bonds by overlap of partially filled *d*-orbitals, they have high m.pt. and b.pt.

**Variable oxidation states :** Due to vacant *d*-orbitals, they exhibit variable oxidation states.

**Coloured compounds :** Due to presence of unpaired electrons which undergo *d-d* transitions, their compounds are coloured.

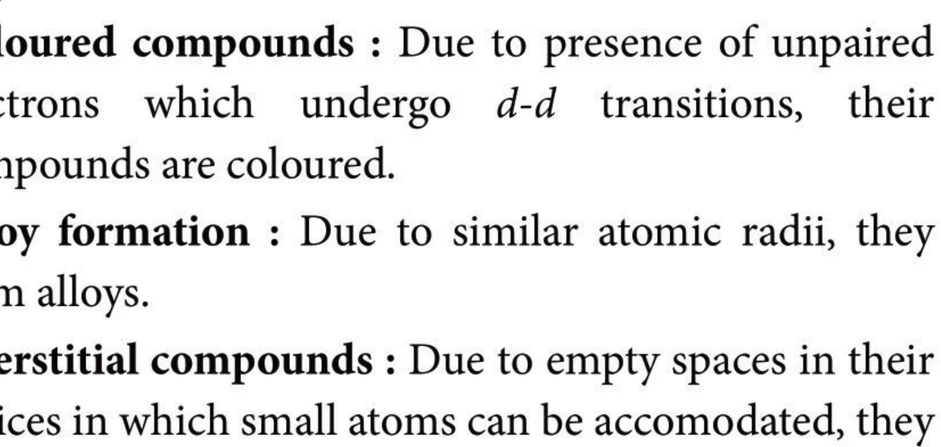
**Alloy formation :** Due to similar atomic radii, they form alloys.

**Interstitial compounds :** Due to empty spaces in their lattices in which small atoms can be accomodated, they form interstitial compounds.

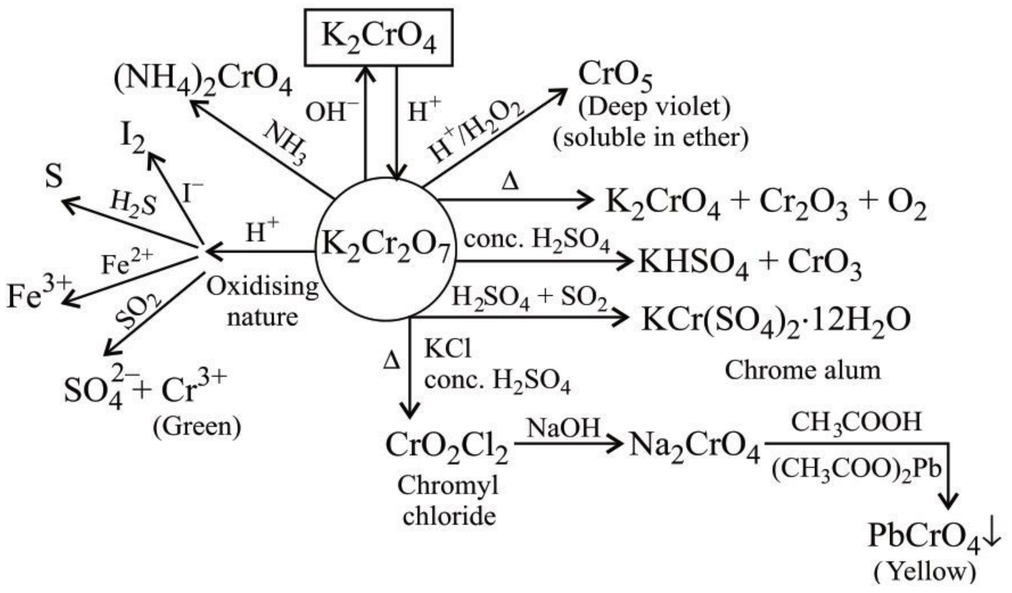
## Some Important Compounds of Transition Elements

### Potassium Dichromate ($K_2Cr_2O_7$)

- **Preparation :**



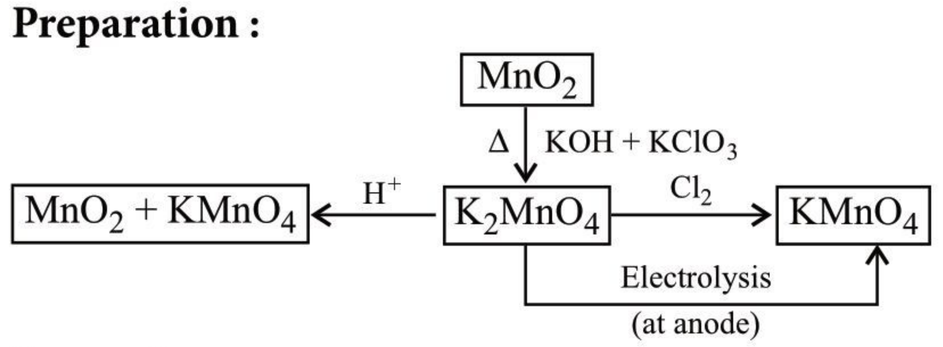

- **Properties :**



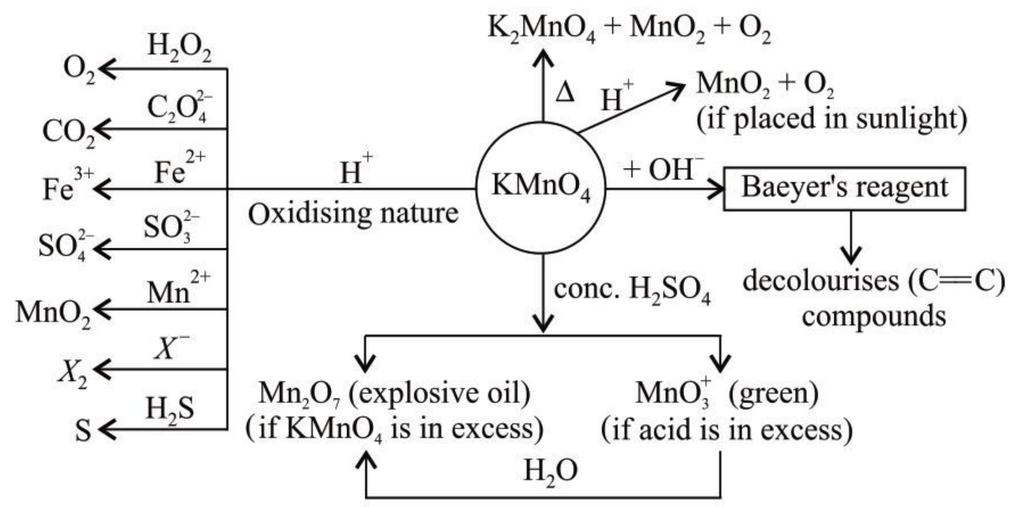

- **Uses :** It is used
  - in dyeing and calico printing,
  - in chrome tanning in leather industry,
  - as a volumetric reagent in laboratory for the estimation of ferrous ions, iodide ions, etc.

### Potassium Permanganate ($KMnO_4$)

- **Preparation :**




- **Properties :**




- **Uses :** It is used
  - as an oxidising agent in the laboratory and industry,
  - as a disinfectant and germicide,
  - in qualitative and quantitative analysis.

## Inner Transition Elements (*f*-Block Elements)

- **Lanthanoids :** The elements with atomic numbers 58 to 71 *i.e.*, cerium to lutetium (which come immediately after lanthanum, $Z = 57$) are called lanthanoids.

- **Actinoids :** The elements with atomic numbers 90 to 103 *i.e.*, thorium to lawrencium (which come immediately after actinium, $Z = 89$) are called actinoids.
- They are called *f*-block elements because last electron enters into *f*-orbital.
- **General electronic configuration :**
  $(n-2)f^{1-14}\,(n-1)d^{0-1}\,ns^2$

## Electronic Configuration

| Element (Lantha-noids) | Electronic configuration | Element (Actinoids) | Electronic configuration |
|---|---|---|---|
| La (57) | $[Xe]5d^16s^2$ | Ac (89) | $[Rn]6d^17s^2$ |
| Ce (58) | $[Xe]4f^15d^16s^2$ | Th (90) | $[Rn]6d^27s^2$ |
| Pr (59) | $[Xe]4f^36s^2$ | Pa (91) | $[Rn]5f^26d^17s^2$ |
| Nd (60) | $[Xe]4f^46s^2$ | U (92) | $[Rn]5f^36d^17s^2$ |
| Pm (61) | $[Xe]4f^56s^2$ | Np (93) | $[Rn]5f^46d^17s^2$ |
| Sm (62) | $[Xe]4f^66s^2$ | Pu (94) | $[Rn]5f^67s^2$ |
| Eu (63) | $[Xe]4f^76s^2$ | Am (95) | $[Rn]5f^77s^2$ |
| Gd (64) | $[Xe]4f^75d^16s^2$ | Cm (96) | $[Rn]5f^76d^17s^2$ |
| Tb (65) | $[Xe]4f^96s^2$ | Bk (97) | $[Rn]5f^97s^2$ |
| Dy (66) | $[Xe]4f^{10}6s^2$ | Cf (98) | $[Rn]5f^{10}7s^2$ |
| Ho (67) | $[Xe]4f^{11}6s^2$ | Es (99) | $[Rn]5f^{11}7s^2$ |
| Er (68) | $[Xe]4f^{12}6s^2$ | Fm (100) | $[Rn]5f^{12}7s^2$ |
| Tm (69) | $[Xe]4f^{13}6s^2$ | Md (101) | $[Rn]5f^{13}7s^2$ |
| Yb (70) | $[Xe]4f^{14}6s^2$ | No (102) | $[Rn]5f^{14}7s^2$ |
| Lu (71) | $[Xe]4f^{14}5d^16s^2$ | Lr (103) | $[Rn]5f^{14}6d^17s^2$ |

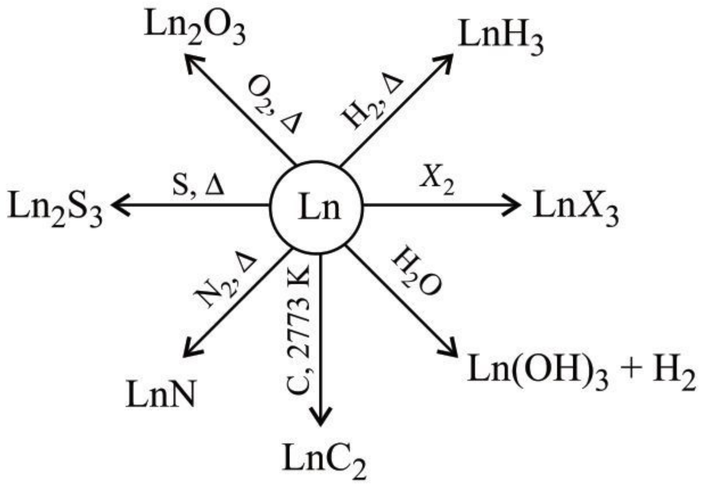
## Lanthanoid Contraction

- A unique feature of lanthanoids is the decrease in atomic and ionic radii from lanthanum to lutetium. The gradual and steady decrease across the period is called lanthanoid contraction.
- **Cause of lanthanoid contraction :** From La to Lu, atomic number increases, number of protons in the nucleus increases and electrons are added to 4*f*-orbitals which have very poor shielding power. It shields the growing nuclear charge imperfectly. As a result, effective nuclear charge increases and radius decreases.
- **Consequences of lanthanoid contraction :**
  - Atomic radii of 2nd and 3rd transition series elements are almost identical due to lanthanoid contraction. *e.g.*, Zr = 160 pm, Hf = 159 pm.
    As a result, they occur in nature together, and their separation from their mixture is difficult.
  - The slight difference in size of lanthanoids is responsible for difference in their properties like solubility and complex ion formation. This difference is utilised in their separation from the mixture of lanthanoids by solvent extraction or ion exchange.

## Differences Between Lanthanoids and Actinoids

| Lanthanoids | Actinoids |
|---|---|
| These exhibit mainly +3 oxidation state. In addition to +3 oxidation state, the lower oxidation state of +2 and higher oxidation state of +4 are noticed. | These also exhibit +3 oxidation state. In addition to +3 states, higher oxidation state +3 to +7 are also noticed. |
| These show lanthanoid contraction. | These show actinoid contraction. |
| Most ions of lanthanoids are colourless. | Most ions of actinoids are coloured. |
| These possess lesser tendency for complex formation. | These possess greater tendency for complex formation. |
| These do not give oxocations. | These give oxocations. *e.g.*, $UO_2^{2+}$. |
| Their compounds are less basic in nature. | Their compounds are more basic in nature. |
| These are not radioactive (only promethium shows radioactivity). | All these are radioactive. |

## Chemical Properties of Lanthanoids



# WRAP it up!

## MCQs TYPE QUESTIONS

1. $P_4O_{10}$ is the anhydride of
   (a) $H_3PO_2$ (b) $H_3PO_3$
   (c) $H_3PO_4$ (d) $H_4P_2O_7$

2. Which of the following shows nitrogen in its increasing order of oxidation number?
   (a) $N_2O < NO < NO_2 < NO_3^- < NH_4^-$
   (b) $NH_4^+ < N_2O < NO < NO_2 < NO_3^-$
   (c) $NH_4^+ < N_2O < NO_2 < NO_3^- < NO$
   (d) $NH_4^+ < NO < N_2O < NO_2 < NO_3^-$

3. Which of the following ions has electronic configuration $[Ar]3d^6$ ?
   (a) $Ni^{3+}$ (b) $Mn^{3+}$ (c) $Fe^{3+}$ (d) $Co^{3+}$
   (At. nos. Mn = 25, Fe = 26, Co = 27, Ni = 28).

4. Which of the following is not correctly matched with the given example?
   (a) An element of first transition series which has highest second ionisation enthalpy-Cu.
   (b) An element of first transition series with highest third ionisation enthalpy-Zn.
   (c) An element of first transition series with lowest enthalpy of atomisation-Zn.
   (d) Last element of third transition series-Cd.

5. Which of the following statements is incorrect regarding the structure of the $ClO_2$ molecule?
   (a) The $ClO_2$ molecule is angular with O—Cl—O bond angle being 118°.
   (b) The two Cl—O bonds lengths are equal.
   (c) Both Cl—O bond lengths are greater than expected for a single Cl—O bond.
   (d) Both Cl—O bond lengths are shorter than expected for a single Cl—O bond.

6. Which one of the following does not correctly represent the correct order of the property indicated against it?
   (a) Ti < V < Cr < Mn : increasing number of oxidation states.
   (b) $Ti^{3+} < V^{3+} < Cr^{3+} < Mn^{3+}$ : increasing magnetic moment.
   (c) Ti < V < Cr < Mn : increasing melting points.
   (d) Ti < V < Mn < Cr : increasing $2^{nd}$ ionisation enthalpy.

7. Interstitial compounds are
   (a) non-stoichiometric and are ionic in nature
   (b) non-stoichiometric and are covalent in nature
   (c) non-stoichiometric and are neither typically ionic nor covalent in nature
   (d) stoichiometric and are neither ionic nor covalent in nature.

8. A gas (*X*) is obtained when copper reacts with dilute $HNO_3$. The gas thus formed reacts with oxygen to give brown fumes of (*Y*). (*Y*) when dissolved in water gives an important acid (*Z*) and the gas (*X*). *X*, *Y* and *Z* respectively are
   (a) NO ; $NO_2$ ; $HNO_3$ (b) $NO_2$ ; NO ; $HNO_3$
   (c) $N_2O$ ; NO ; $HNO_2$ (d) NO ; $N_2O$ ; $HNO_3$

9. The correct order of solubility in water for He, Ne, Ar, Kr, Xe is
   (a) He > Ne > Ar > Kr > Xe
   (b) Xe > Kr > Ar > Ne > He
   (c) Ne > Ar > Kr > He > Xe
   (d) Ar > Ne > He > Kr > Xe

10. **Assertion :** Transition metals are poor reducing agents.
    **Reason :** Transition metals form numerous alloys with other metals.
    (a) Both assertion and reason are true and reason is the correct explanation of assertion.
    (b) Both assertion and reason are true but reason is not the correct explanation of assertion.
    (c) Assertion is true but reason is false.
    (d) Both assertion and reason are false.

11. The correct order of the thermal stability of hydrogen halides is
    (a) HI > HBr > HCl > HF
    (b) HF > HCl > HBr > HI
    (c) HCl < HF > HBr < HI
    (d) HI > HCl > HF > HBr

12. Which of the following is the wrong statement?
    (a) Ozone is a paramagnetic gas.
    (b) The two oxygen -oxygen bond length in ozone are identical.
    (c) $O_3$ molecule is bent.
    (d) Ozone is violet-black in solid state.

**13.** Match the catalyst in column I with the process in column II and select the correction otpion.

| | Column I | | Column II |
|---|---|---|---|
| (i) | $V_2O_5$ | (p) | The oxidation of ethyne to ethanal |
| (ii) | $TiCl_4 + Al(CH_3)_3$ | (q) | Polymerisation of alkynes |
| (iii) | $PdCl_2$ | (r) | Oxidation of $SO_2$ in the manufacture of $H_2SO_4$ |
| (iv) | Nickel complexes | (s) | Polymerisation of ethylene |

(a) (i)-(r), (ii)-(s), (iii)-(p), (iv)-(q)
(b) (i)-(p), (ii)-(q), (iii)-(r), (iv)-(s)
(c) (i)-(p), (ii)-(r), (iii)-(q), (iv)-(s)
(d) (i)-(r), (ii)-(p), (iii)-(s), (iv)-(q)

**14.** Match the column I with column II and mark the appropriate choice.

| Column I | | Column II | |
|---|---|---|---|
| (A) | Laughing gas | (i) | Hydrazoic acid |
| (B) | Anhydride of $HNO_3$ | (ii) | Nitrous oxide |
| (C) | Anhydride of $HPO_3$ | (iii) | Nitrogen pentoxide |
| (D) | Acid hydride of nitrogen | (iv) | Phosphorus pentoxide |

(a) (A) → (i), (B) → (ii), (C) → (iii), (D) → (iv)
(b) (A) → (iv), (B) → (i), (C) → (ii), (D) → (iii)
(c) (A) → (ii), (B) → (iii), (C) → (iv), (D) → (i)
(d) (A) → (iii), (B) → (iv), (C) → (i), (D) → (ii)

**15.** Oxygen is more electronegative than sulphur. Yet $H_2S$ is acidic while $H_2O$ is neutral. This is because
(a) water is a highly associated compound
(b) molecular mass of $H_2S$ is more than that of $H_2O$
(c) $H_2S$ is gaseous under ordinary conditions while $H_2O$ is a liquid
(d) H — S bond is weaker than H — O bond.

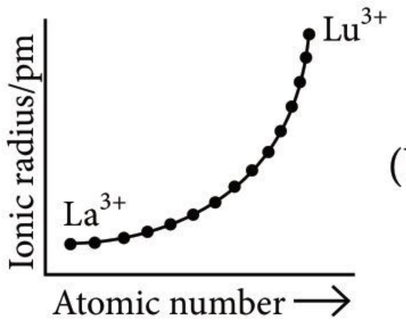
**16.** Identify the incorrect statement among the following.
(a) 4*f* and 5*f* orbitals are equally shielded.
(b) *d*-block elements show irregular and erratic chemical properties among themselves.
(c) La and Lu have partially filled *d*-orbitals and no other partially filled orbitals.
(d) The chemistry of various lanthanoids is very similar.

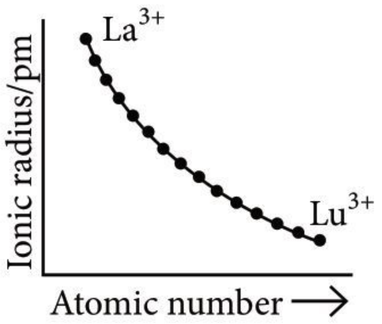
**17.** **Assertion :** Acidic character of group 16 hydrides increases from $H_2O$ to $H_2Te$.
**Reason :** Thermal stability of hydrides decreases down the group.
(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Both assertion and reason are false.

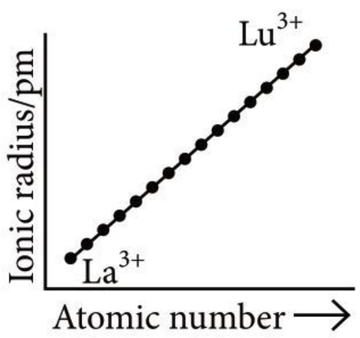
**18.** An aqueous solution of a gas shows following reactions :
(i) It turns red litmus blue.
(ii) When added in excess to a copper sulphate solution a deep blue colour is obtained.
(iii) On addition to ferric chloride solution a brownish precipitate soluble in $HNO_3$ is obtained.
Identify the gas.
(a) $SO_2$ (b) $SO_3$ (c) $NH_3$ (d) $CO_2$

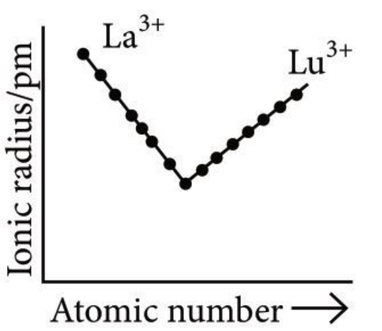
**19.** Which of the following statements is wrong?
(a) $Ti^{4+}$ and $Ag^+$ are repelled by magnetic field.
(b) $Mn^{2+}$ shows maximum magnetic character among the first transition series.
(c) $Fe^{2+}$ is more stable than $Mn^{2+}$ towards oxidation to +3 state.
(d) Cr in $Cr_2O^{2-}_7$ ion involves $sp^3d^2$ hybridisation.

**20.** Which of the following graphs shows correct trends in the size of +3 ions of lanthanides?

(a)



(b)



(c)



(d)



## MONTHLY TEST DRIVE CLASS XI ANSWER KEY

| | | | | |
|---|---|---|---|---|
| **1.** (d) | **2.** (b) | **3.** (c) | **4.** (d) | **5.** (c) |
| **6.** (a) | **7.** (d) | **8.** (a) | **9.** (d) | **10.** (c) |
| **11.** (c) | **12.** (d) | **13.** (b) | **14.** (d) | **15.** (d) |
| **16.** (b) | **17.** (d) | **18.** (d) | **19.** (b) | **20.** (a,c) |
| **21.** (b,c) | **22.** (b,d) | **23.** (a,c,d) | **24.** (5) | **25.** (56) |
| **26.** (3) | **27.** (b) | **28.** (b) | **29.** (c) | **30.** (d) |

## NUMERICAL VALUE TYPE QUESTIONS

**21.** The total number of compounds having at least one bridging oxo group among the molecules given below is _____ .

$N_2O_5, P_4O_6, P_4O_7, H_4P_2O_5, H_5P_3O_{10}, H_2S_2O_3, H_2S_2O_7$

**22.** To measure the quantity of $MnCl_2$ dissolved in an aqueous solution, it was completely converted to $KMnO_4$ using the reaction,

$MnCl_2 + K_2S_2O_8 + H_2O \rightarrow KMnO_4 + H_2SO_4 + HCl$ (equation not balanced)

Few drops of concentrated HCl were added to this solution and gently warmed. Further, oxalic acid (225 mg) was added in portions till the colour of the permanganate ion disappeared. The quantity of $MnCl_2$ (in mg) present in the initial solution is _____ .

(Atomic weights in g $mol^{-1}$: Mn = 55, Cl = 35.5)

**23.** How many ions among the following will be coloured in an aqueous solution?
$Ti^{3+}$, $V^{3+}$, $Cu^{+}$, $Sc^{3+}$, $Mn^{2+}$ and $Fe^{3+}$

**24.** The number of moles of acidified $KMnO_4$ required to convert one mole of sulphite ion into sulphate ion is $x/y$. $(x + y)$ is _____.

**25.** The percentage of *p*-character in the orbitals forming P – P bonds in $P_4$ is _____.

## SOLUTIONS

**1. (c) :** $P_4O_{10} + 6H_2O \longrightarrow \underset{\text{Orthophosphoric acid}}{4H_3PO_4}$

**2. (b) :** $N_2O = +1$, $NO = +2$, $NO_2 = +4$, $NO_3^- = +5$, $NH_4^+ = -3$

Increasing order of oxidation state will be

$NH_4^+ < N_2O < NO < NO_2 < NO_3^-$

**3. (d) :** The electronic configurations of the given ions are:

$Ni^{3+} : [Ar]3d^7 4s^0$, $Mn^{3+} : [Ar]3d^4 4s^0$

$Fe^{3+} : [Ar]3d^5 4s^0$, $Co^{3+} : [Ar]3d^6 4s^0$

Thus, $Co^{3+}$ is the ion with the desired configuration.

**4. (d) :** Hg is the last element of third transition series.

**5. (c) :** Due to delocalization of electrons on three atoms, the Cl—O bond length decreases.

**6. (c)** **7. (c)**

**8. (a) :** $3Cu + 8HNO_{3(dil.)} \rightarrow 3Cu(NO_3)_2 + \underset{(X)}{2NO} + 4H_2O$

$\underset{(X)}{2NO} + O_2 \rightleftharpoons \underset{(Y)}{2NO_2}$

$\underset{(Y)}{3NO_2} + H_2O \rightarrow \underset{(Z)}{2HNO_3} + \underset{(X)}{NO}$

**9. (b) :** As the size of the noble gas atoms increases down the group, the polarisation of the electron cloud becomes easier. So, heavier noble gas atoms are easily polarised in polar water. Thus, solubility increases down the group.

**10. (b)** **11. (b)**

**12. (a) :** Ozone is diamagnetic gas.

**13. (a)** **14. (c)**

**15. (d) :** H—S bond is weaker than H—O bond thus, $H_2S$ has higher tendency to release proton.

**16. (a)** **17. (b)**

**18. (c) :** The gas (*X*) is $NH_3$.

(i) Its aqueous solution is $NH_4OH$ which turns red litmus to blue.

(ii) $CuSO_4 + 2NH_4OH \longrightarrow Cu(OH)_2 + (NH_4)_2SO_4$

$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \longrightarrow \underset{\substack{\text{Tetrammine copper (II)}\\ \text{sulphate (blue copper)}}}{[Cu(NH_3)_4]SO_4} + 4H_2O$

(iii) $FeCl_3 + 3NH_4OH \longrightarrow \underset{\text{Brownish ppt.}}{Fe(OH)_3} + 3NH_4Cl$

$Fe(OH)_3 + 3HNO_3 \longrightarrow \underset{\text{Soluble}}{Fe(NO_3)_3} + 3H_2O$

**19. (c)**

**20. (b) :** On increasing the atomic number of lanthanoid, there is regular decrease of ionic size due to poor shielding of 4*f* electrons (lanthanoid contraction).

**21. (5)** **22. (126)** **23. (4)**

**24. (7) :** $\underset{\text{2 moles}}{2MnO_4^-} + 6H^+ + 5SO_3^{2-} \rightarrow 2Mn^{2+} + \underset{\text{5 moles}}{5SO_4^{2-}} + 3H_2O$

5 moles of $SO_3^{2-} \equiv$ 2 moles of $MnO_4^-$

1 mole of $SO_3^{2-} \equiv$ 2/5 moles of $MnO_4^-$

$\equiv$ 2/5 moles of $KMnO_4$

$x + y = 2 + 5 = 7$

**25. (75)**

# CBSE warm-up!

CLASS-XII

**Chapterwise practice questions for CBSE Exams as per the latest pattern and reduced syllabus by CBSE for the academic session 2022-23.**

**Series-7**

## Alcohols, Phenols and Ethers

Time Allowed : 3 hours
Maximum Marks : 70

### GENERAL INSTRUCTIONS

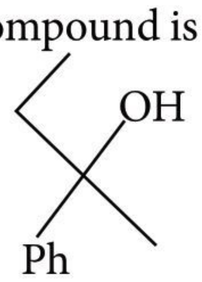
***General Instructions : Read the following instructions carefully.***

*(a) There are 35 questions in this question paper with internal choice.*
*(b) SECTION A consists of 18 multiple-choice questions carrying 1 mark each.*
*(c) SECTION B consists of 7 very short answer questions carrying 2 marks each.*
*(d) SECTION C consists of 5 short answer questions carrying 3 marks each.*
*(e) SECTION D consists of 2 case- based questions carrying 4 marks each.*
*(f) SECTION E consists of 3 long answer questions carrying 5 marks each.*
*(g) All questions are compulsory.*
*(h) Use of log tables and calculators is not allowed.*

### SECTION A

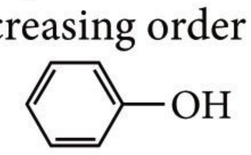
**The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.**

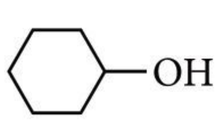
**1.** Correct IUPAC name of the following compound is

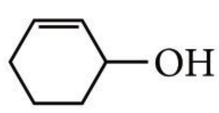


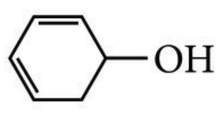

(a) 3-phenylbutan-3-ol
(b) 2-phenylpropan-2-ol
(c) 2-phenylbutan-2-ol
(d) 3-phenylbutan-2-ol.

**2.** Dehydration of the following compounds in increasing order is

(I) 


(II) 

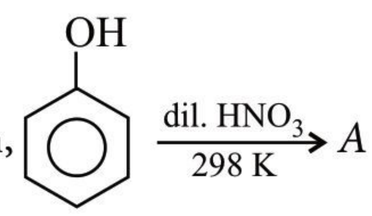

(III) 


(IV) 

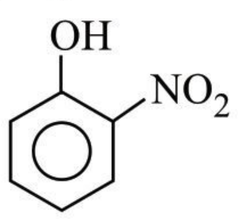

(a) I < II < III < IV
(b) II < III < IV < I
(c) I < III < IV < II
(d) none of these.

**3.** Anisole on reaction with chloromethane in presence of anhydrous $AlCl_3$ gives

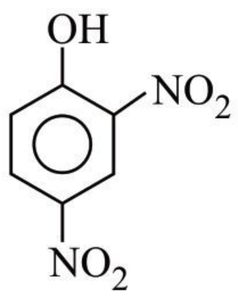
(a) *o*-methyl anisole and *p*-methoxy anisole
(b) *p*-methyl anisole and *p*-methoxy anisole
(c) *o*-methyl anisole and *p*-methyl anisole
(d) *o*-methoxy acetophenone and *p*-methoxy acetophenone.

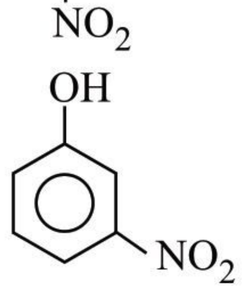
**4.** In the given reaction, 


Major product *A* is

(a) 

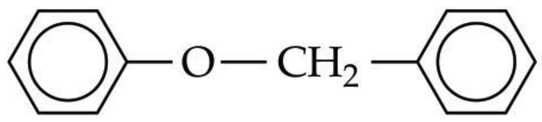

(b) 

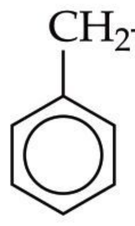
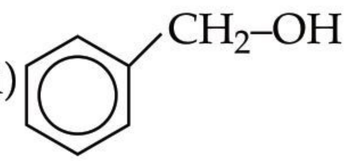
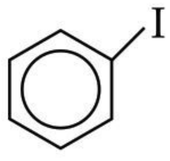

(c) 


(d) 

**5.** Phenols are highly acidic compared to alcohols due to
(a) the higher molecular mass of phenols
(b) the stronger hydrogen bonds in phenols
(c) alkoxide ion is a strong conjugate base
(d) phenoxide ion is resonance stabilised.

**6.** The ether that undergoes electrophilic substitution reaction is
(a) $CH_3OC_2H_5$ (b) $C_6H_5OCH_3$
(c) $CH_3OCH_3$ (d) $C_2H_5OC_2H_5$

**7.** The given ether, 
when reacts with cold HI gives mixture of

(i) 
(ii) 
(iii) 
(iv) 

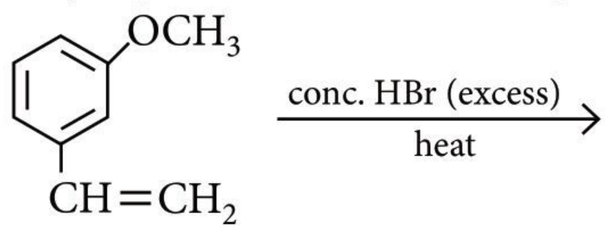
(a) (iii) and (iv) (b) (i) and (ii)
(c) (ii) and (iii) (d) (i) and (iv).

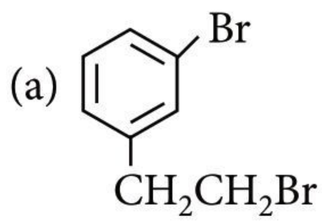
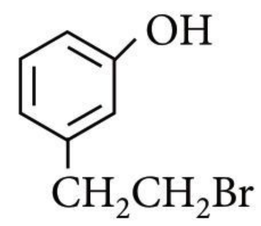
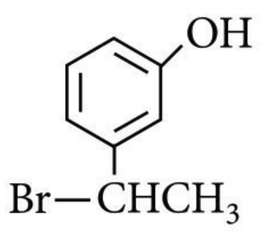
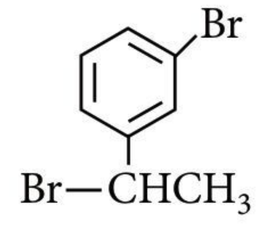
**8.** When an aqueous solution of benzene diazonium chloride is heated with dilute sulphuric acid the compound formed is
(a) benzene (b) chlorobenzene
(c) phenol (d) aniline.

**9.** Arrange the following alcohols in order of increasing reactivity towards sodium metal.
(i) $(CH_3)_3C-OH$ (ii) $(CH_3)_2CH-OH$
(iii) $CH_3CH_2OH$
(a) (iii) < (ii) < (i) (b) (ii) < (i) < (iii)
(c) (i) < (ii) < (iii) (d) (iii) < (i) < (ii)

**10.** Boiling point of ethyl alcohol is greater than ether due to
(a) van der Waals' forces (b) London forces
(c) polarity (d) hydrogen bonding.

**11.** Which of the following is an unsymmetrical ether?
(a) $CH_3-O-C_3H_7$ (b) $CH_3-O-CH_3$
(c) $C_2H_5-O-C_2H_5$ (d) All of these.

**12.** The major product of the following reaction is


(a) 
(b) 
(c) 
(d) 

**13.** Phenol reacts with bromine in carbon disulphide at low temperature to give
(a) *m*-bromophenol
(b) *p*-bromophenol
(c) *o*-and *p*-bromophenol
(d) 2, 4, 6-tribromophenol.

**14.** In alcohols, oxygen atom is
(a) $sp^2$-hybridised (b) *sp*-hybridised
(c) $sp^3d$-hybridised (d) $sp^3$-hybridised.

**15.** Given below are two statements labelled as Assertion (A) and Reason (R).
**Assertion :** Alcohols turn blue litmus red.
**Reason :** Alcohols give red colour with ceric ammonium nitrate solution.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**16.** Given below are two statements labelled as Assertion (A) and Reason (R).
**Assertion :** *o*-Nitrophenol is more volatile than *p*-nitrophenol.
**Reason :** Intramolecular hydrogen bonding is present in *o*-nitrophenol while intermolecular H-bonding in *p*-nitrophenol.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**17.** Given below are two statements labelled as Assertion (A) and Reason (R).
**Assertion :** *t*-Butyl methyl ether is not prepared by the reaction of *t*-butyl bromide with sodium methoxide.
**Reason :** Sodium methoxide is a strong nucleophile.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**18.** Given below are two statements labelled as Assertion (A) and Reason (R).
**Assertion :** Dehydration of glycerol with $KHSO_4$ gives acrolein.
**Reason :** Acrolein is an α, β-unsaturated aldehyde.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

## SECTION B

**This section contains 7 questions with internal choice in two questions. The following questions are very short answer type and carry 2 marks each.**

**19.** How will you convert :
**(a)** Propene to propan-2-ol
**(b)** Phenol to 2,4,6-trinitrophenol?

**20.** Write the structure of the products when butan-2-ol reacts with the following :
**(a)** $CrO_3$ **(b)** $SOCl_2$

**OR**

**(a)** Write the mechanism of the following reaction :

$$CH_3CH_2OH \xrightarrow{HBr} CH_3CH_2Br + H_2O$$

**(b)** Write the equation involved in Reimer–Tiemann reaction.

**21.** Give simple chemical tests to distinguish between the following pairs of compounds:
**(a)** Ethanol and phenol
**(b)** Propanol and 2-methylpropan-2-ol.

**OR**

Write the final product(s) in each of the following reactions :

**(a)** $CH_3CH_2-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3 \xrightarrow{Cu/573\ K}$

**(b)** $C_6H_5-OH \xrightarrow[(ii)\ H^+]{(i)\ CHCl_3 + aq.\ NaOH}$

**22.** Account for the following :
**(a)** Phenols do not give protonation reactions readily.
**(b)** Boiling points of phenols are higher than corresponding aryl halide, ether or arenes of comparable molecular masses.

**23.** What happens when
**(a)** ethyl alcohol reacts with red P and $Br_2$
**(b)** oxidation of propan-1-ol occurs with alkaline $KMnO_4$ solution?

**24.** **(a)** How will you convert ethanol to ethoxyethane?
**(b)** What are the conditions for preparation of ethers from alcohols?

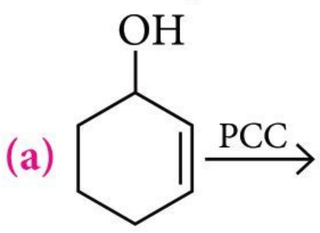
**25.** An ether would possess a dipole moment even if the alkyl groups present in it are identical. Explain.

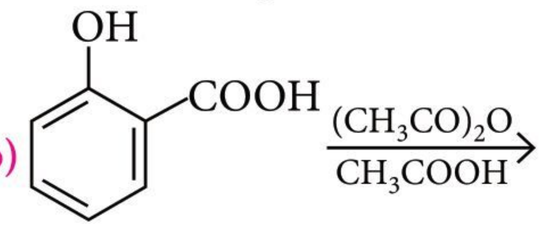
## SECTION C

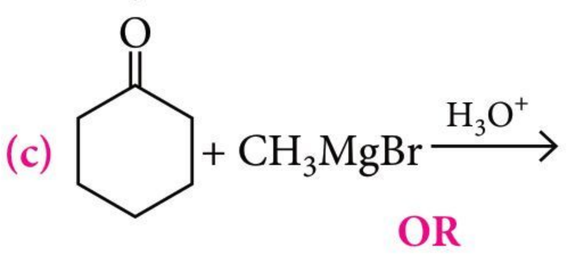
**This section contains 5 questions with internal choice in two questions. The following questions are short answer type and carry 3 marks each.**

**26.** Explain :
**(a)** The $C\overset{O}{\frown}H$ bond angle in alcohol is slightly less than the tetrahedral angle.
**(b)** Alcohols are highly soluble in water.
**(c)** Solubility of alcohols in water decreases with increasing size of alkyl group.

**27.** Write the product(s) of the following reactions :

**(a)** 


**(b)** 


**(c)** 


**OR**

**(a)** Give chemical tests to distinguish between Pentan-2-ol and Pentan-3-ol.
**(b)** *o*-Nitrophenol is more acidic than *o*-methoxyphenol. Explain why.
**(c)** What is absolute alcohol?

**28.** Predict the products of the following reactions:

**(a)** $CH_3-CH=CH_2 \xrightarrow[(ii)\ 3H_2O_2/OH^-]{(i)\ B_2H_6} ?$

**(b)** $C_6H_5OH \xrightarrow{Br_2(aq)} ?$ **(c)** $CH_3CH_2OH \xrightarrow{Cu/573K} ?$

**29.** **(a)** Phenols are stronger acids than alcohols, why?
**(b)** Draw resonance structures of phenol and phenoxide ion.

**30.** Give reasons for **any three** of the following:
**(a)** Preparation of ethers by acidic dehydration of secondary or tertiary alcohols is not a suitable method.
**(b)** Phenylmethyl ether reacts with HI to give phenol and methyl iodide and not iodobenzene and methyl alcohol.
**(c)** Boiling point of ethanol is higher in comparison to methoxymethane.
**(d)** Phenol does not give nucleophilic substitution reaction easily as compared to alcohols.

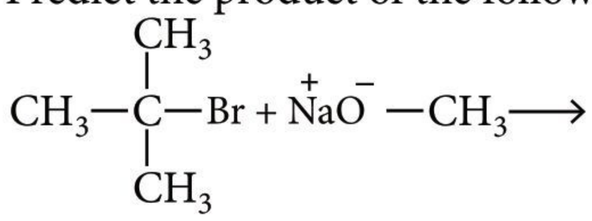
## SECTION D

**The following questions are case-based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.**

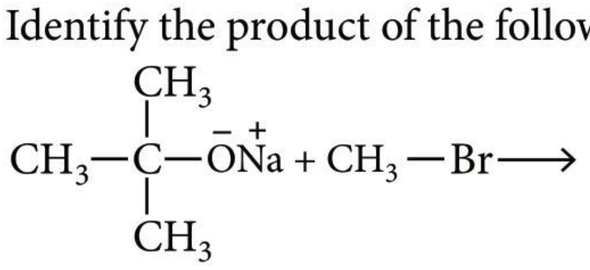
**31.** Williamson's synthesis is used for the preparation of symmetrical as well as unsymmerical ethers. The reaction follows $S_N2$ reaction mechanism. In Williamson's synthesis, 1° alkyl halides are used for preparation of ethers because 2° and 3° alkyl halides give alkene. Ethers are cleaved by hydrogen halides to form alcohol and alkyl halide where alkyl halide corresponds to that alkyl group which has less number of carbon atoms (it is because of less steric hindrance). In polar medium, an unsymmetrical ether like tertiary butyl ethyl ether gives ethyl alcohol and tertiary butyl halide as reaction proceeds *via* carbocation intermediate.

**Answer the following questions :**

**(a)** Predict the product of the following reaction :



**(b)** Identify the product of the following reaction :



**(c)** Why is Williamson's synthesis not applicable to tertiary halides?

**OR**

How can you convert phenol into an alkyl aryl ether?

**32.** Alcohols undergo dehydration to form alkenes on treating with a protic acid, *e.g.*, conc. $H_2SO_4$ or catalysts such as anhydrous zinc chloride or alumina. Oxidation of alcohols involves the formation of a carbon oxygen double bond with cleavage of O—H and C—H bonds. A better reagent for oxidation of primary alcohols to aldehydes in good yield is pyridinium chlorochromate (PCC), a complex of chromium trioxide with pyridine and HCl. In phenol, the reaction that take place on the aromatic ring is electrophilic substitution reactions.

**Answer the following questions :**

**(a)** How do you convert ethanol to propan-2-ol?
**(b)** Why phenol undergoes electrophilic substitution more easily than benzene?
**(c)** Write mechanism of the following reaction :

$$C_2H_5OH \xrightarrow[443\,K]{H_2SO_4} CH_2 = CH_2 + H_2O$$

**OR**

Explain the mechanism of acid catalysed hydration of an alkene to form corresponding alcohol.

## SECTION E

**The following questions are long answer type and carry 5 marks each. Two questions have an internal choice.**

**33.** **(a)** Write the reaction and state the conditions for each of the following conversions :
(i) Propene to propanol.
(ii) Chlorobenzene to phenol.
**(b)** Write the reaction and the conditions only for the commercial preparation of phenol from cumene.

**OR**

**(a)** Write chemical equations and reaction conditions for the conversion of phenol to
(i) phenyl ethanoate (ii) ethoxybenzene.
**(b)** How are primary, secondary and tertiary alcohols distinguished?

### UNSCRAMBLED WORDS

**NOVEMBER 2022**

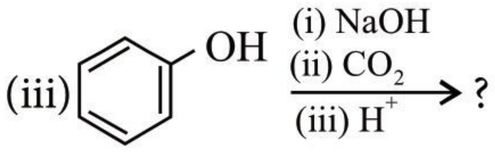
| | |
|---|---|
| 1-d- FERMENTATION | 2-i- ANTIPYRETIC |
| 3-g- VULCANISATION | 4-h- METALLURGY |
| 5-a- SPELTER | 6-b- CAPROLACTUM |
| 7-j- QUENCHING | 8-e- EUDIOMETER |
| 9-f- POLYDENTATE | 10-c- OCCLUSION |

***Winner :*** *Nisha Rawat*

**34. (a)** Write the product(s) in the following reactions :

(i) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-O-CH_2-CH_3 \xrightarrow{HI} ? + ?$

(ii) $CH_3-CH=CH-CH_2-OH \xrightarrow{PCC} ?$

(iii) 


**(b)** How do you convert the following?

(i) Phenol to anisole (ii) Aniline to phenol

**OR**

**(a)** Account for the following :

(i) Why is it that phenol is acidic and hexanol is neutral towards a solution of NaOH?

(ii) *t*-butyl chloride on heating with sodium methoxide gives 2-methylpropene instead of *t*-butylmethylether.

**(b)** Anisole undergoes bromination with bromine and ethanoic acid even in absence of iron bromide catalyst. Why?

**35. (a)** Write the formula of reagents used in the following reactions :

(i) Bromination of phenol to 2,4,6-tribromophenol

(ii) Hydroboration of propene and then oxidation to propanol.

**(b)** Arrange the following compounds in the increasing order of their property indicated :

(i) *p*-nitrophenol, ethanol, phenol (acidic character)

(ii) propanol, propane, propanal (boiling point)

**(c)** Write the mechanism (using curved arrow notation) of the following reaction:

$$CH_3-CH_2-\overset{+}{O}H_2 \xrightarrow{CH_3CH_2OH} ?$$

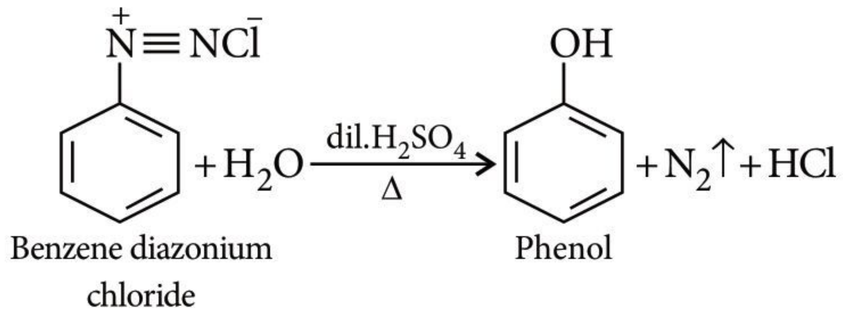
$$CH_3-CH_2-\underset{\displaystyle H}{\overset{+}{\underset{|}{O}}}-CH_2-CH_3 + H_2O$$

## SOLUTIONS

**1.** (c) **2.** (a) **3.** (c) **4.** (a)

**5.** (d) **6.** (b) **7.** (b)

**8. (c) :**




Benzene diazonium chloride — Phenol

**9.** (c) **10.** (d)

**11. (a) :** Mixed or unsymmetrical ethers are those ethers, in which both the alkyl or aryl groups attached to oxygen atom are different.

**12.** (c) **13.** (c) **14.** (d)

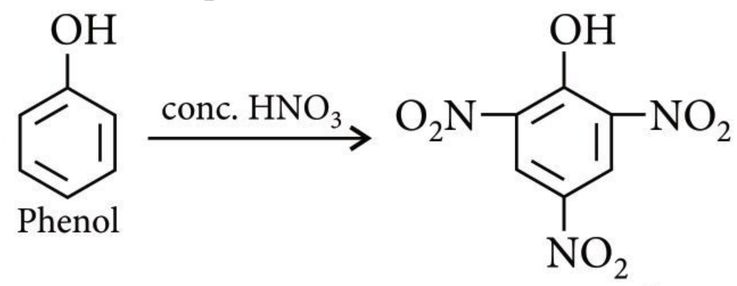
**15. (d) :** Alcohols are weakly acidic and hence do not turn blue litmus red. Ceric ammonium nitrate test is an analytical test for alcohols. Alcohols give red colour with ceric ammonium nitrate solution.

**16.** (a) **17.** (b) **18.** (b)

**19. (a)** $CH_3CH=CH_2 \xrightarrow[H_2O]{H_2SO_4} CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$

Propene — Propan-2-ol

**(b)**




Phenol — Picric acid (2,4,6-Trinitrophenol)

**20. (a)** $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_2-CH_3 \xrightarrow{CrO_3} CH_3-\overset{\displaystyle O}{\overset{||}{C}}-CH_2CH_3$

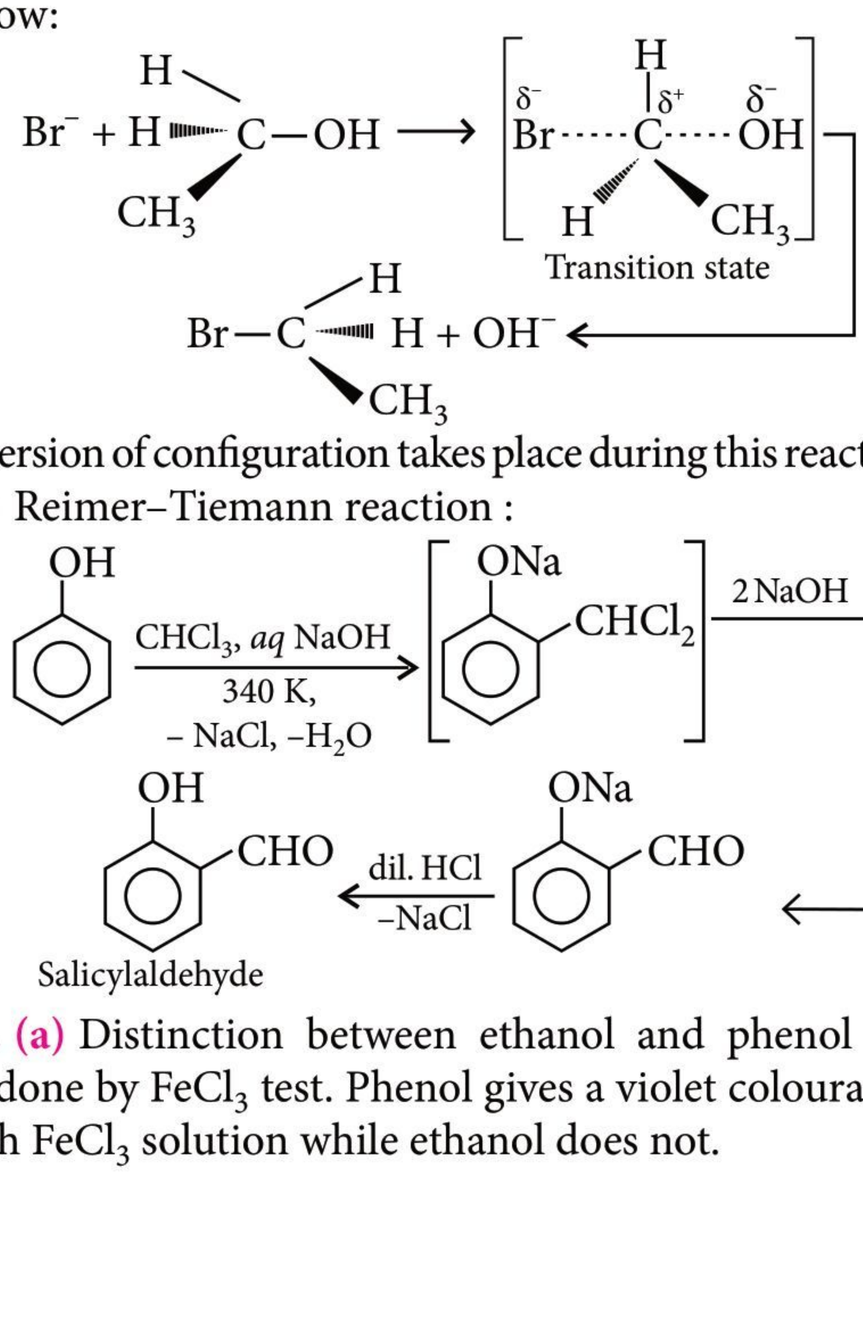
Butan-2-ol — Butan-2-one

**(b)** $CH_3-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_2-CH_3 \xrightarrow{SOCl_2} CH_3-\underset{\displaystyle Cl}{\underset{|}{CH}}-CH_2-CH_3$

Butan-2-ol — 2-Chlorobutane

**OR**

**(a)** The reaction proceeds through nucleophilic substitution bimolecular ($S_N2$) mechanism, as shown below:




Inversion of configuration takes place during this reaction.

**(b)** Reimer–Tiemann reaction :




Salicylaldehyde

**21. (a)** Distinction between ethanol and phenol can be done by $FeCl_3$ test. Phenol gives a violet colouration with $FeCl_3$ solution while ethanol does not.

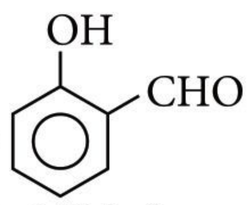
$$6C_6H_5OH + FeCl_3 \longrightarrow \underset{\text{Violet colouration}}{[Fe(C_6H_5O)_6]^{3+}} + 3H^+ + 3HCl$$
Phenol

$$C_2H_5OH + FeCl_3 \longrightarrow \text{No violet colouration}$$

**(b)** Propanol (1° alcohol) and 2-methylpropan-2-ol (3° alcohol) can be distinguished by Lucas test. With Lucas reagent (conc. HCl and anhyd. $ZnCl_2$), 1° alcohol show no cloudiness, while 3° alcohols show cloudiness immediately.

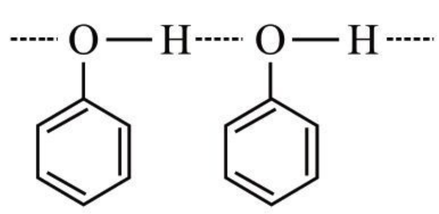
**OR**

**(a)** $CH_3CH_2-\underset{\underset{OH}{|}}{CH}-CH_3 \xrightarrow{Cu/573\ K} CH_3CH_2-\overset{\overset{O}{||}}{C}-CH_3$
Butan-2-one

**(b)** $C_6H_5-OH \xrightarrow[(ii)\ H^+]{(i)\ CHCl_3 + aq\ NaOH}$ 
Salicylaldehyde

**22. (a)** Due to electron withdrawing effect of phenyl group, the electron density on the oxygen atom of — OH group in phenols is less. Hence, phenols do not undergo protonation.

**(b)** The high boiling point of phenol is mainly due to presence of intermolecular hydrogen bonding.



**23. (a)** $\underset{\text{Ethyl alcohol}}{CH_3CH_2OH} \xrightarrow{Red\ P + Br_2} \underset{\text{Ethyl bromide}}{CH_3CH_2Br} + H_3PO_3$

**(b)** $\underset{\text{Propan-1-ol}}{CH_3CH_2CH_2OH} \xrightarrow{KMnO_4/OH^-} CH_3CH_2CHO \xrightarrow{KMnO_4/OH^-} CH_3CH_2COOH$

**24. (a)** $\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[413\ K]{H_2SO_4} \underset{\text{Ethoxyethane}}{C_2H_5-O-C_2H_5}$

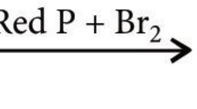
**(b)** Conditions for the preparation of ethers from alcohols are:

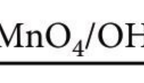
(i) only 1° alcohol should be taken.

(ii) alkyl group should be unhindered.

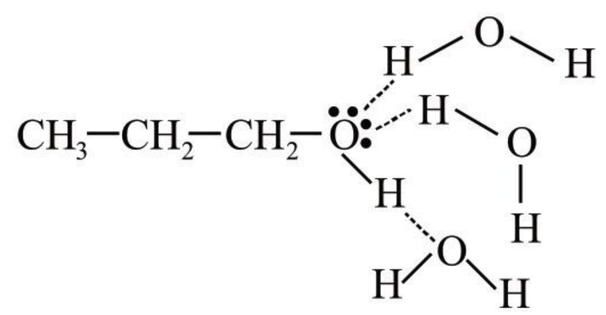
(iii) temperature should be kept low.

**25.** Due to the bent structure of ethers and polarity of C – O bond, all ethers have a net dipole moment.

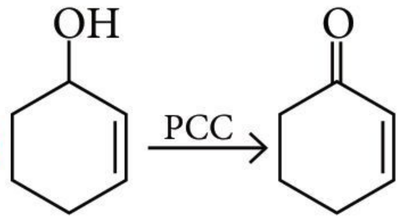


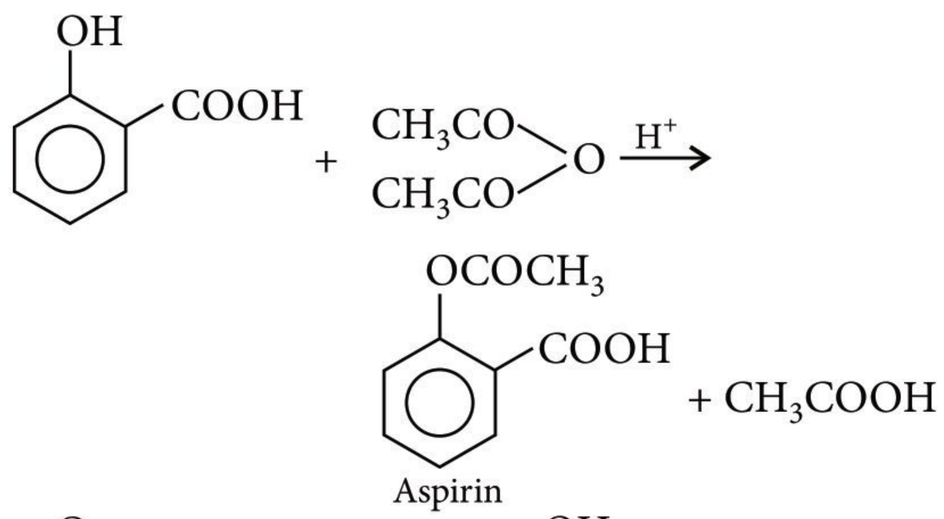
**26. (a)** The bond angle  in alcohol is slightly less than tetrahedral angle due to the repulsion between the unshared electron pairs of oxygen.

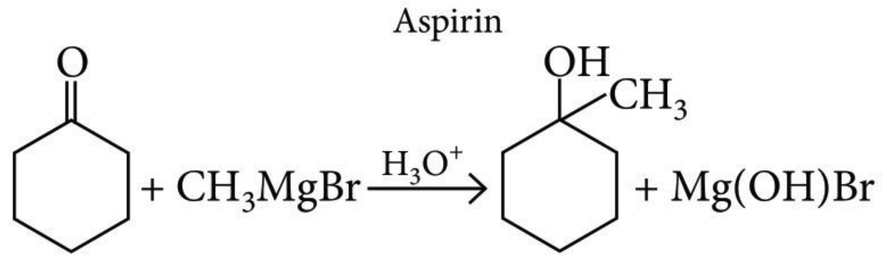
**(b)** Alcohols are soluble in water due to formation of H–bonds with water molecules. Example,



**(c)** Alkyl groups are hydrophobic in nature. So, as size of alkyl group increases, its solubility in water decreases.

**27. (a)** 

**(b)** 
Aspirin

**(c)** 

**OR**

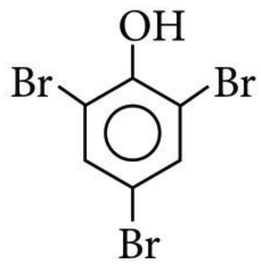
**(a)** On adding $I_2$ and NaOH, 2-pentanol will give yellow precipitate of iodoform whereas 3-pentanol will not give yellow precipitate.

$$\underset{\underset{\text{Pentan-2-ol}}{\underset{OH}{|}}}{CH_3-CH-CH_2CH_2CH_3} \xrightarrow{I_2 + NaOH} \underset{\text{Yellow ppt.}}{CHI_3} + CH_3CH_2CH_2COONa$$

**(b)** As we know that the electron withdrawing groups enhance the acidic character of phenols because they help in the stabilisation of phenoxide ion by dispersing negative charge. Nitro group is an electron withdrawing group whereas methoxy group destabilise the phenoxide ion by intensifying the negative charge. Thus, *o*-nitrophenol is more acidic than *o*-methoxyphenol.

**(c)** 100% ethanol is known as absolute alcohol.

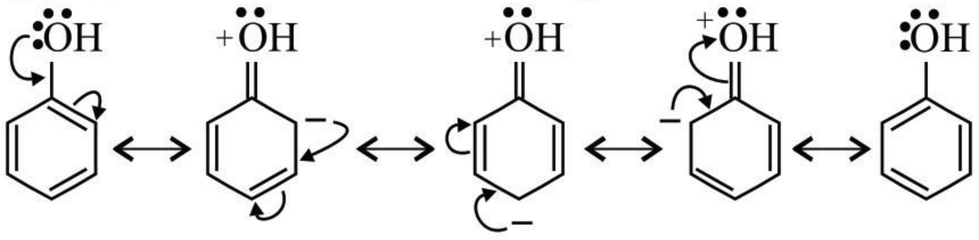
**28. (a)** $CH_3-CH=CH_2 \xrightarrow[(ii)\ 3H_2O_2/OH^-]{(i)\ B_2H_6} CH_3CH_2CH_2OH$

**(b)** $C_6H_5OH \xrightarrow{Br_2(aq)}$ 
2,4,6-Tribromophenol

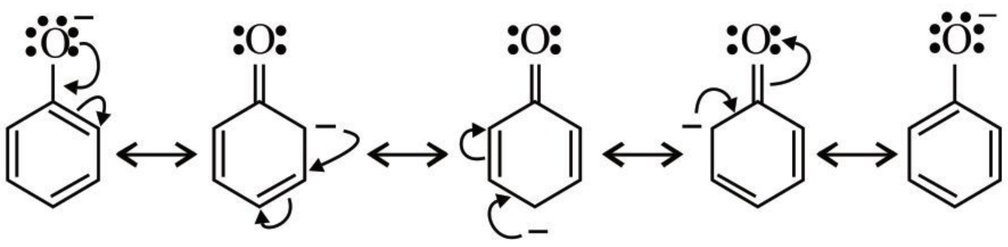
**(c)** $CH_3CH_2OH \xrightarrow{Cu/573\ K} CH_3CHO$

**29. (a)** In alcohols, —OH group is attached to electron releasing alkyl group which decreases the polarity of O—H bond while in phenols —OH group is attached to electron withdrawing phenyl group which increases the polarity of O— H bond.

**(b)** (I) Resonance structures of phenol

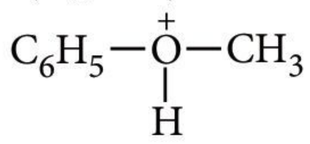


(II) Resonance structures of phenoxide ion



**30. (a)** Acidic dehydration of 2° and 3° alcohols give alkenes rather than ethers. Due to steric hindrance, the nucleophilic attack by the alcohol molecule on the protonated alcohol molecule does not occur. The protonated 2° and 3° alcohols lose water molecules to form stable 2° and 3° carbocations.

**(b)** Protonation of anisole (phenyl methyl ether) gives methyl phenyl oxonium ion.

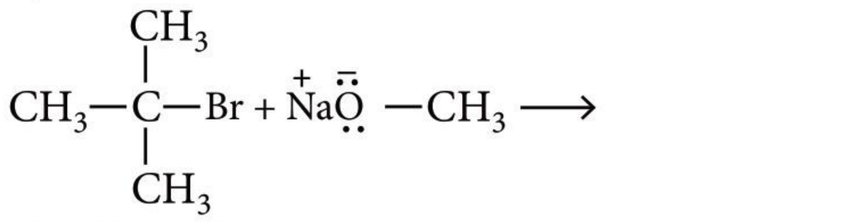


In this ion, the stronger bond is O—$C_6H_5$. Therefore, attack by $I^-$ ion exclusively breaks the weaker O—$CH_3$ bond forming methyl iodide and phenol. The phenol formed does not react further to give aryl halides.

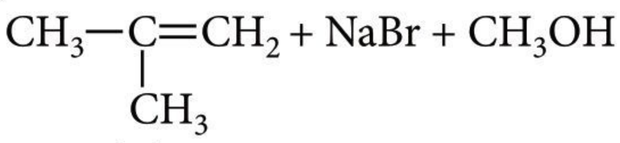
**(c)** Ethanol has higher boiling point because of strong intermolecular hydrogen bonding whereas in methoxymethane, molecules are held by dipole-dipole interactions.

**(d)** The C – O bond in phenol has some double bond character due to resonance and hence cannot be easily cleaved by a nucleophile. In contrast, the C – O bond in alcohols is a pure single bond and hence can be easily cleaved by a nucleophile.

**31. (a)**

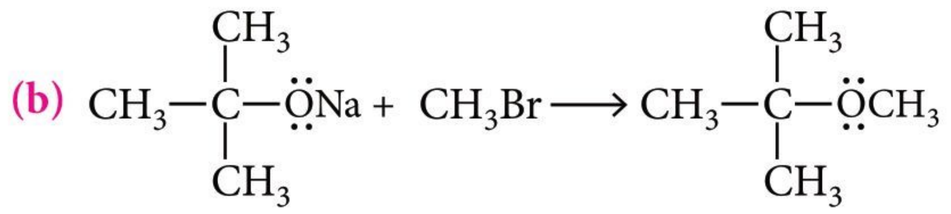


*t*-Butyl bromide



2-Methylpropene

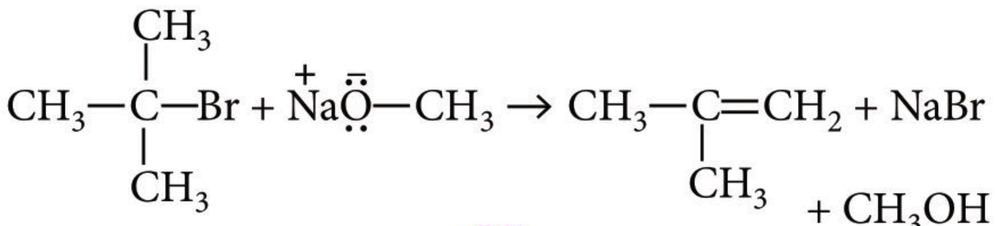
**(b)**



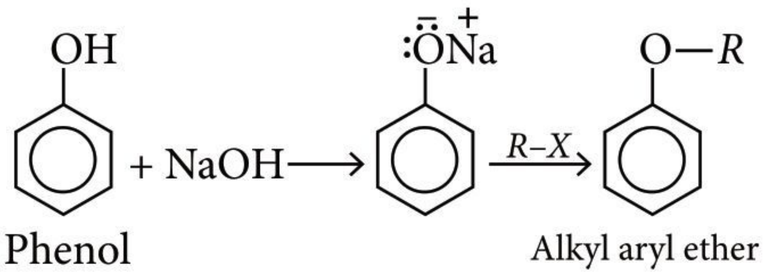
Sodium *tert*-butoxide  2-Methoxy-2-methylpropane

**(c)** In case of secondary or tertiary alkyl halides, elimination competes over substitution and product formed is alkene.

For example,



**OR**

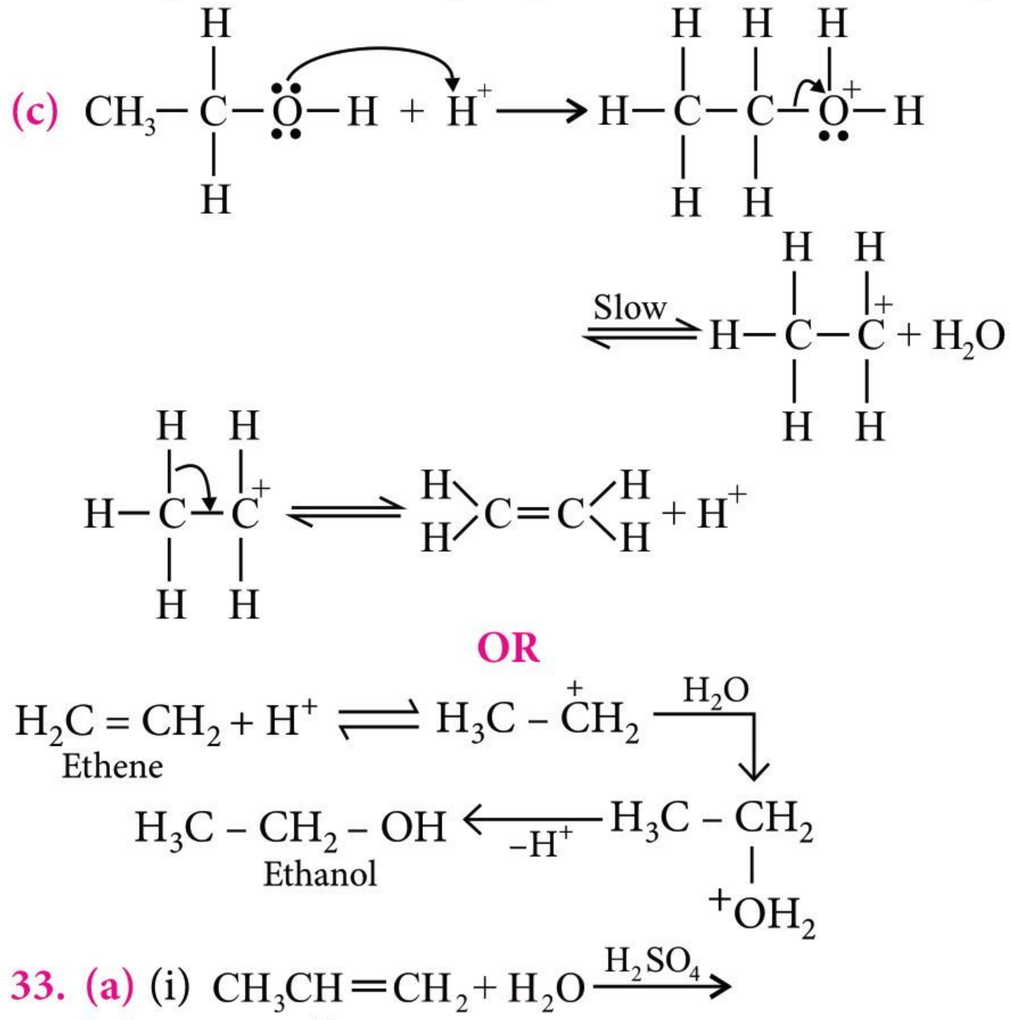


Phenol  Alkyl aryl ether

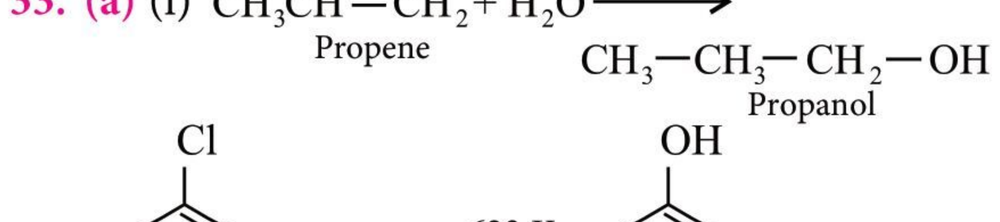
**32. (a)** $CH_3CH_2OH \xrightarrow{PCC} CH_3CHO \xrightarrow[H_2O]{CH_3MgBr} CH_3\underset{\text{Propan-2-ol}}{\underset{|}{\overset{OH}{\overset{|}{C}}}}HCH_3$

**(b)** Phenols undergo electrophilic substitution reactions more easily than benzene due to strong activating effect of –OH group attached to benzene ring.

**(c)**



**OR**



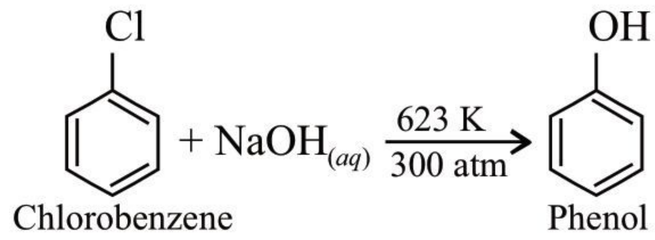
Ethene  Ethanol

**33. (a)** (i)



Propene  Propanol

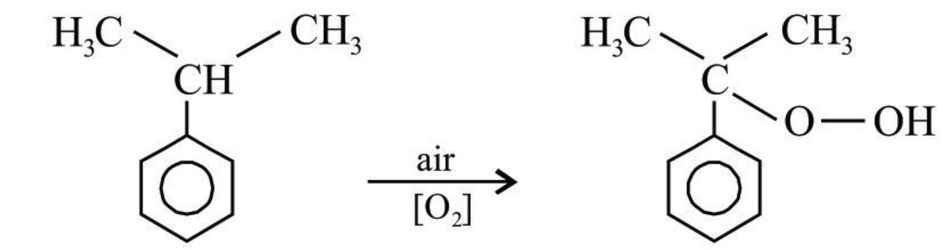
(ii)



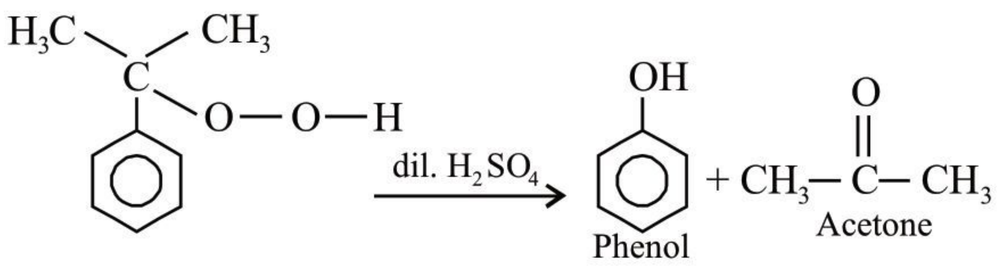
Chlorobenzene  Phenol

**(b)** The process of obtaining phenol from cumene is described in the following steps :

(I) Cumene is oxidised in presence of air to form cumene hydroperoxide.

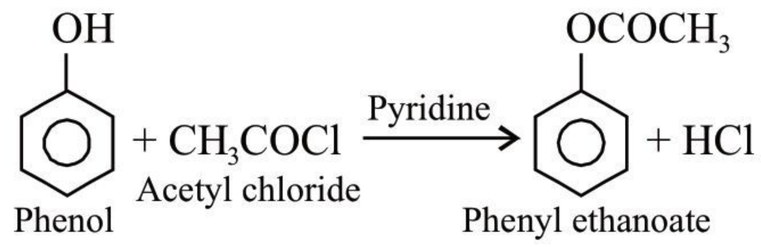



(II) Cumene hydroperoxide is hydrolysed by dilute sulphuric acid which gives phenol and acetone.

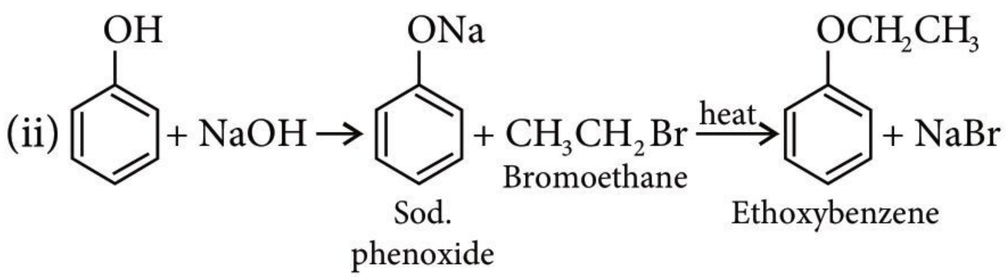



**OR**

**(a)** (i)




(ii)




**(b)** Lucas test : Alcohols react with concentrated hydrochloric acid in presence of anhydrous zinc chloride to form alkyl halides.

$R - OH + HCl \xrightarrow{ZnCl_2} R - Cl + H_2O$

Three types of alcohols undergo this reaction at different rates. The rates of reaction with Lucas reagent [conc. $HCl + ZnCl_2$ (anhydrous)] follow the given order :

Tertiary alcohol > Secondary alcohol > Primary alcohol

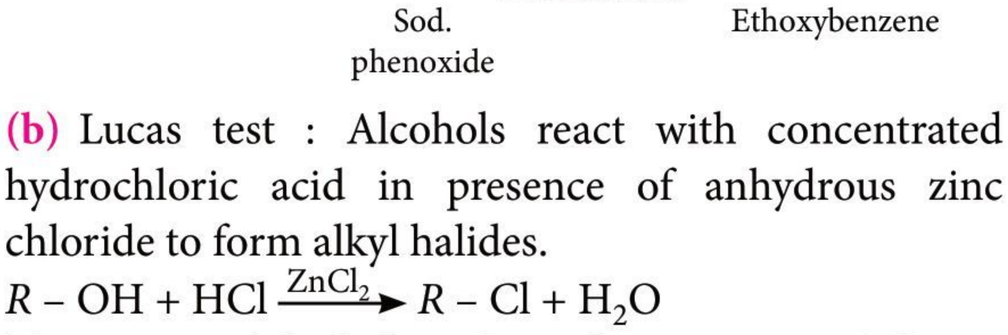
The following observations are made

(I) If cloudiness appears immediately, the alcohol is tertiary.

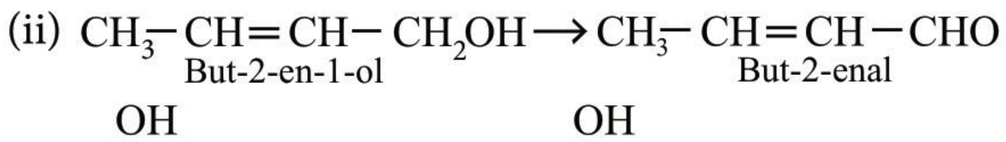
(II) If cloudiness appears within 5-10 minutes, the alcohol is secondary.

(III) If the solution remains clear, *i.e.*, no cloudiness is formed, the alcohol is primary.

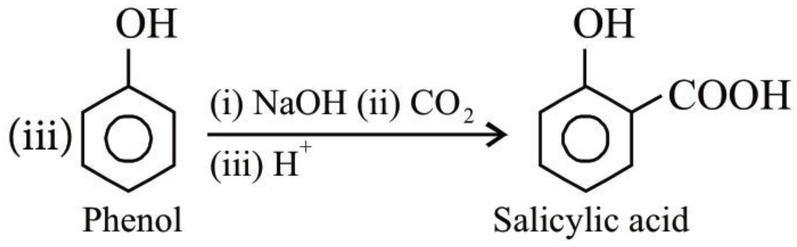
**34. (a)** (i)



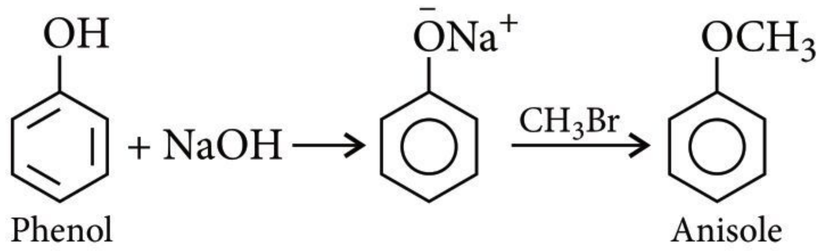

(ii)



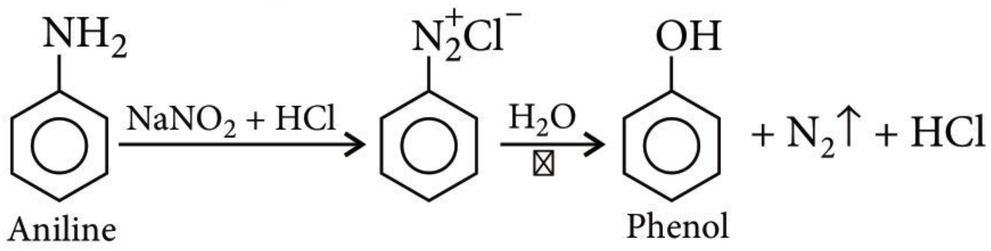

(iii)




**(b)** (i) Phenol to anisole :




(ii) Aniline to phenol :



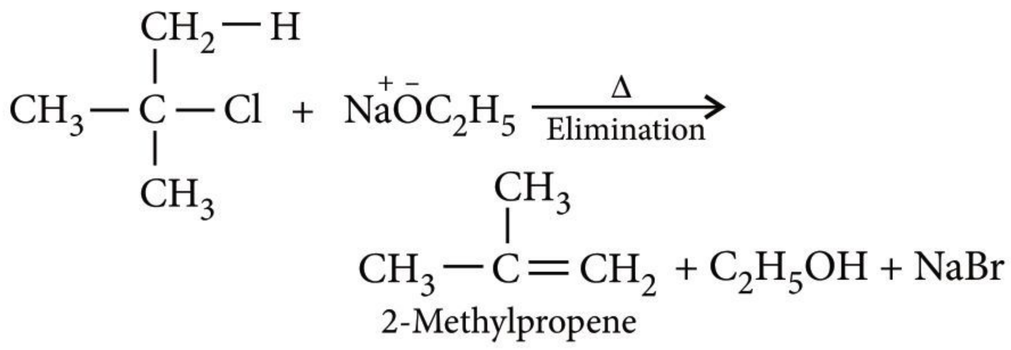

**OR**

**(a)** (i) The phenoxide ion formed after loss of proton from phenol is resonance stabilised and thus phenol loses $H^+$ ion to show acidic character.

$$C_6H_5OH \longrightarrow \underset{\text{Resonance stabilised}}{C_6H_5O^-} + H^+$$

On the other hand, alkoxide ion (formed from hexanol) shows no such resonance stabilisation and is unstable.

(ii) This is because *tert*-alkyl halides undergo elimination instead of substitution.



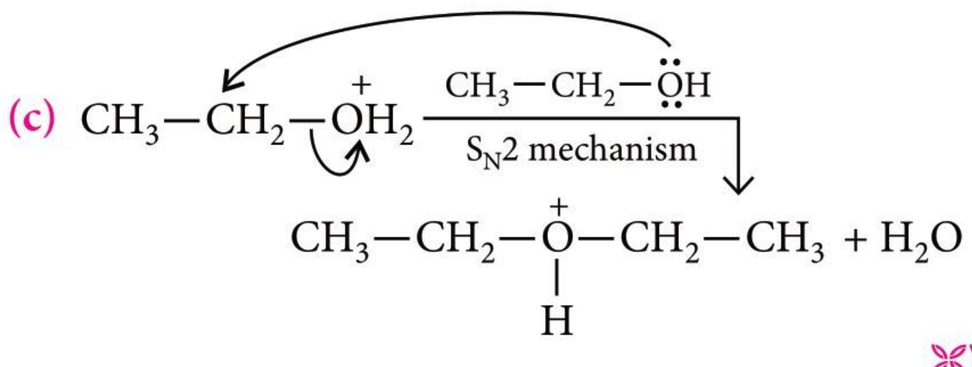

**(b)** Anisole undergoes bromination with bromine and ethanoic acid even in absence of iron(III) bromide catalyst due to activation of benzene ring by the methoxy group.

**35. (a)** (i) $Br_2/H_2O$ (ii) $BH_3$ in $THF/H_2O_2, OH^-$

**(b)** (i) Ethanol < phenol < *p*-nitrophenol

(ii) Propane < propanal < propanol

**(c)**



# MONTHLY TEST DRIVE

This specially designed column enables students to self analyse their extent of understanding the specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

## The Solid State | Solutions

Time Taken : 60 Min.

**NEET**

**Only One Option Correct Type**

**1.** Which of the following statements is not correct?
(a) The number of carbon atoms in a unit cell of diamond is 8.
(b) The number of Bravais lattices in which a crystal can be categorized is 14.
(c) The fraction of the total volume occupied by the atoms in a primitive cell is 0.48.
(d) Molecular solids are generally volatile.

**2.** Choose the correct statement about Henry's constant.
(a) Higher the value of $K_H$ at a given pressure, higher is the solubility of the gas.
(b) Higher the value of $K_H$ at a given pressure, lower is the solubility of the gas.
(c) $K_H$ is not a function of nature of gas.
(d) $K_H$ value for all gases is same at a given pressure.

**3.** If three elements *X*, *Y* and *Z* crystallise in a *ccp* lattice with *X* atoms at the corners, *Y* atoms at the cube centre and *Z* atoms at the edges, the formula of the compound will be
(a) *XYZ* (b) $XYZ_2$ (c) $XYZ_3$ (d) $X_2Y_2Z$

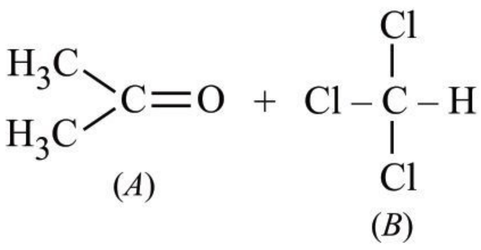
**4.** A 5.25% (*w*/*v*) solution of a substance is isotonic with a 1.5% (*w*/*v*) solution of urea (molar mass = 60 g $mol^{-1}$) in the same solvent. If the densities of both the solutions are assumed to be 1.0 g $cm^{-3}$, the molar mass of the substance will be
(a) 210.0 g $mol^{-1}$ (b) 90.0 g $mol^{-1}$
(c) 115.0 g $mol^{-1}$ (d) 105.0 g $mol^{-1}$

**5.** Which of the following statements is not correct?
(a) 5% aqueous solutions of NaCl and KCl are said to be isomolar.
(b) 1 M sucrose solution and 1 M glucose solution are isotonic.
(c) Molecular masses of acetic acid and benzoic acid are higher than normal mass in cryoscopic methods.
(d) For the same concentration solution, $\frac{\Delta T_b}{\Delta T_f} = \frac{K_b}{K_f}$.

**6.** Arrange the following solutions in increasing order of their osmotic pressures.
(i) 34.2 g/litre of sucrose
(ii) 60 g/litre of urea (iii) 90 g/litre of glucose
(iv) 58.5 g/litre of sodium chloride
(a) (i) < (iii) < (ii) < (iv)
(b) (iii) < (i) < (iv) < (ii)
(c) (i) < (iii) < (iv) < (ii)
(d) (ii) < (iv) < (i) < (iii)

**7.** What is the effect of Frenkel defect on the density of ionic solids?
(a) The density of the crystal increases.
(b) The density of the crystal decreases.
(c) The density of the crystal remains unchanged.
(d) There is no relationship between the density of a crystal and the defect present in it.

**8.** When acetone and chloroform are mixed together, which of the following observations is concluded?




(a) *A* – *A* and *B* – *B* interactions are stronger than *A* – *B* interactions.
(b) *A* – *A* and *B* – *B* interactions are weaker than *A* – *B* interactions.
(c) *A* – *A*, *B* – *B* and *A* – *B* interactions are equal.
(d) The liquids form separate layers and are immiscible.

**9.** A metal of density $7.5 \times 10^3$ kg $m^{-3}$ has an *fcc* crystal structure with lattice parameter *a* = 400 pm. Calculate the number of unit cells present in 0.015 kg of the metal.
(a) $6.250 \times 10^{22}$ (b) $3.125 \times 10^{23}$
(c) $3.125 \times 10^{22}$ (d) $1.563 \times 10^{22}$

**10.** The mole fraction of nitrogen, in a mixture containing 70 grams of nitrogen, 120 grams of oxygen and 44 grams of carbon dioxide is
(a) 0.39 (b) 0.34 (c) 0.29 (d) 5.0

**11.** Total volume of atoms present in a *fcc* unit cell of a metal with radius *r* is
(a) $\frac{12}{3}\pi r^3$ (b) $\frac{16}{3}\pi r^3$ (c) $\frac{20}{3}\pi r^3$ (d) $\frac{24}{3}\pi r^3$

**12.** van't Hoff factor of equimolal solutions of sodium chloride, barium chloride and glucose in water are respectively
(a) 2, 3 and 0 (b) 2, 3 and 6
(c) 2, 3 and 4 (d) 2, 3 and 1

### Assertion & Reason Type

**Directions :** In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

**13.** **Assertion :** Face centred cubic cell has 4 atoms per unit cell.
**Reason :** It has one atom at the corners $\left(\frac{1}{8}\times 8=1\right)$ and 3 atoms at the faces $\left(\frac{1}{2}\times 6=3\right)$.

**14.** **Assertion :** In osmosis, movement of molecules occurs in one direction while in diffusion, movement occurs in all directions.
**Reason :** In osmosis, a semipermeable membrane is used while diffusion occurs without membrane.

**15.** **Assertion :** In an ideal solution, $\Delta_{mix}H$ is zero.
**Reason :** In an ideal solution, $A - B$ interactions are lower than $A - A$ and $B - B$ interactions.

## JEE MAIN / JEE ADVANCED

### Only One Option Correct Type

**16.** Which is not the correct statement for ionic solids in which positive and negative ions are held by strong electrostatic attractive forces?
(a) The radius ratio, $r_+/r_-$ increases as coordination number increases.
(b) As the difference in size of ions increases, coordination number increases.
(c) When coordination number is eight, $r_+/r_-$ ratio lies between 0.225 to 0.414.
(d) In ionic solids of the type *AX* (ZnS, Wurtzite), the coordination number of $Zn^{2+}$ and $S^{2-}$ respectively are 4 and 4.

**17.** Vapour pressure of pure water at 298 K is 23.8 mm Hg. 50 g of urea is dissolved in 850 g of water. The vapour pressure of water for this solution and its relative lowering are respectively
(a) 23.8 mm Hg and 0.16
(b) 25.4 mm Hg and 0.02
(c) 30.2 mm Hg and 0.020
(d) 23.4 mm Hg and 0.017

**18.** A metal crystallises into two cubic systems, face centred cubic (*fcc*) and body centred cubic (*bcc*), whose unit cell lengths are 3.5 Å and 3.0 Å respectively. The ratio of densities of *fcc* and *bcc* is
(a) 1.259 : 1 (b) 1 : 1.259
(c) 3 : 2 (d) 1.142 : 1

**19.** An element crystallises into a structure which may be described by a cubic type of unit cell having one atom on each corner of the cube and two atoms on one of its diagonals. If the volume of this unit cell is $24\times10^{-24}$ cm$^3$ and density of element is 7.2 g cm$^{-3}$, the number of atoms present in 200 g of element is
(a) $3.5\times10^{24}$ (b) $5.7\times10^{23}$
(c) $6.3\times10^{20}$ (d) $1\times10^{10}$

### More than One Option Correct Type

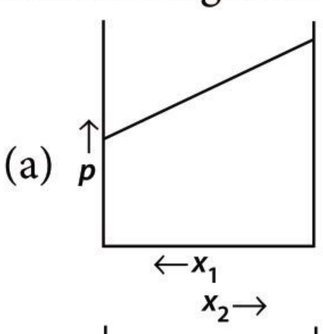
**20.** Which of the following is not true about the voids formed in 3 dimensional hexagonal close packed structure?
(a) A tetrahedral void is formed when a sphere of the second layer is present above triangular void in the first layer.
(b) All the triangular voids are not covered by the spheres of the second layer.
(c) Tetrahedral voids are formed when the triangular voids in the second layer lie above the triangular voids in the first layer and the triangular shapes of these voids do not overlap.
(d) Octahedral voids are formed when the triangular voids in the second layer exactly overlap with similar voids in the first layer.

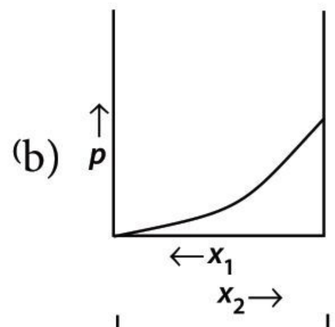
**21.** Relative lowering of vapour pressure is a colligative property because
(a) it depends on the concentration of a non-electrolyte solute in solution and not on the nature of the solute molecules
(b) it depends on number of particles of electrolyte solute in solution and not on the nature of the solute particles
(c) it depends on the concentration of a non-electrolyte solute in solution as well as the nature of the solute molecules

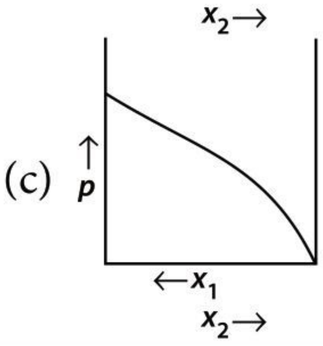
(d) it depends on the concentration of an electrolyte or non-electrolyte solute in solution as well as the nature of solute molecules

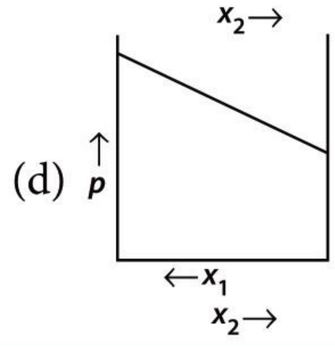
**22.** Which statements is/are true about *hcp* and *ccp* lattice?
(a) Number of tetrahedral voids are twice of octahedral voids.
(b) 12 tetrahedral and 6 octahedral voids are present in one *hcp* unit cell.
(c) C.N. of *hcp* unit cell is 12.
(d) If an atom of tetrahedral voids displaces into octahedral voids, then it is a Schottky defect.

**23.** For a binary ideal liquid solution, the variation in total vapour pressure versus composition of solution is given by which of the curves?

(a) 


(b) 


(c) 


(d) 


## Integer / Numerical Value Type

**24.** The edge length of a face centred cubic cell of ionic substance is 508 pm. If the radius of the cation is 110 pm, then the radius of the anion is _____pm.

**25.** Calculate (in gram) the amount of $CaCl_2$ ($i = 2.47$) dissolved in 2.5 litre of water such that its osmotic pressure is 0.75 atm at 27°C.

**26.** The Henry's law constant for solubility of $N_2$ gas in water at 298 K is $1 \times 10^5$ atm. The mole fraction of $N_2$ in air is 0.8. The number of moles of $N_2$ from air dissolved in 10 moles of water at 298 K and 5 atm pressure is $x \times 10^{-4}$. Then the value of $x$ is _____.

## Comprehension Type

Dissolution of solids in water can be exothermic or endothermic process but gases always dissolve in water with the evolution of heat. Dissolution of a substance in water can be either because of ion-dipole interactions or by hydrogen bond formation. Pressure plays a significant role in the solubility of gases in water. Solubility of a gas in terms of mole fraction ($x$) and is related to pressure ($p$) according to the mathematical relation, $p = K_H x$.

**27.** The value of $K_H$ for $N_2$ gas in water at 298 K is 86.76 kbar, the value of $K_H$ for $N_2$ in water at 303 K (in kbar) is
(a) 86.76 (b) > 86.76
(c) < 86.76 (d) unpredictable.

**28.** Solubility of KCl in water increases with the rise in temperature. This means that $\Delta_{diss}H$ of KCl in water is
(a) 0 (b) < 0
(c) > 0 (d) unpredictable.

## Matching Type

**29.** Match the column I with column II and select the correct option.

| Column I (Position of atom) | | Column II (Contribution of atom per unit cell) | |
|---|---|---|---|
| (A) | Corner | (i) | 1 |
| (B) | Edge | (ii) | 1/8 |
| (C) | Face centre | (iii) | 1/4 |
| (D) | Body centre | (iv) | 1/2 |

(a) (A) → (ii), (B) → (i), (C) → (iii), (D) → (iv)
(b) (A) → (ii), (B) → (iii), (C) → (iv), (D) → (i)
(c) (A) → (i), (B) → (ii), (C) → (iv), (D) → (iii)
(d) (A) → (iii), (B) → (iv), (C) → (i), (D) → (ii)

**30.** Match the column I with column II and select the correct option.

| Column I | | Column II | |
|---|---|---|---|
| (A) | $\Delta H_{mix} = 0, \Delta V_{mix} = 0$ | (i) | Non-ideal solution |
| (B) | $\Delta H_{mix} \neq 0, \Delta V_{mix} \neq 0$ | (ii) | Positive deviation |
| (C) | $\Delta H_{mix} < 0, \Delta V_{mix} < 0$ | (iii) | Ideal solution |
| (D) | $\Delta H_{mix} > 0, \Delta V_{mix} > 0$ | (iv) | Negative deviation |

(a) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)
(b) (A) → (iii), (B) → (i), (C) → (iv), (D) → (ii)
(c) (A) → (ii), (B) → (iii), (C) → (iv), (D) → (i)
(d) (A) → (iii), (B) → (ii), (C) → (i), (D) → (iv)

*Keys are published in this issue. Search now!* ☺

**SELF CHECK**

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

**Check your score! If your score is**

| | | |
|---|---|---|
| > 90% | EXCELLENT WORK ! | You are well prepared to take the challenge of final exam. |
| 90-75% | GOOD WORK ! | You can score good in the final exam. |
| 74-60% | SATISFACTORY ! | You need to score more next time. |
| < 60% | NOT SATISFACTORY! | Revise thoroughly and strengthen your concepts. |

# WORD GRID

Readers are requested to send their responses of word grid. Be the Winner!

Find and encircle the words in the given grid, running in one of the possible directions; horizontal, vertical or diagonal by reading the clues given below.

| A | Q | Y | F | R | C | O | A | G | U | L | A | T | I | O | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | P | R | M | E | T | A | L | L | O | I | D | S | O | L | S |
| R | M | T | N | G | R | T | N | I | R | V | U | T | Q | P | L |
| N | A | S | U | G | I | M | J | K | H | J | M | Q | S | O | S |
| M | C | I | N | A | D | F | E | L | M | A | R | A | F | P | U |
| L | S | M | T | L | U | V | Z | N | N | D | I | S | J | C | R |
| Y | U | E | C | L | T | W | H | M | T | B | S | P | T | Q | F |
| V | D | H | E | O | I | L | X | W | K | A | O | B | G | K | A |
| L | N | C | R | T | V | A | L | Z | S | C | T | W | U | O | C |
| V | C | O | R | R | O | S | I | O | N | F | O | I | D | X | T |
| B | E | T | W | O | P | Y | N | A | I | U | P | K | O | D | A |
| R | Z | O | M | P | O | K | E | R | S | D | E | I | T | N | N |
| F | M | H | S | E | I | U | Q | P | U | H | Y | B | X | G | T |
| J | Y | P | V | L | Q | X | G | J | W | L | T | N | O | H | C |

## Clues

1. Any of two or more physical forms in which an element can exist.
2. A process in which a solid, especially a metal, is eaten away and changed by a chemical action.
3. A chemical reaction in which a ferment causes an organic molecule to split into simpler substances, especially the anaerobic conversion of sugar to ethyl alcohol by yeast.
4. Element with a different number of neutrons than standard.
5. The clumping of particles in order to settle down impurities; often induced by chemicals such as lime or alum.
6. The branch of chemistry concerned with the chemical effects of light and other electromagnetic radiations.
7. A surface-active substance, such as a detergent or soap, that lowers the surface tension of a solvent (usually water).
8. Elements whose properties are intermediate between those of metals and solid non-metals or semiconductors.

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